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Evaluation of Emission Sources at a Waferboard Manufacturing Plant

(U.S.) Radian Corp., Research Triangle Park, NC

Prepared for

Environmental Protection Agency
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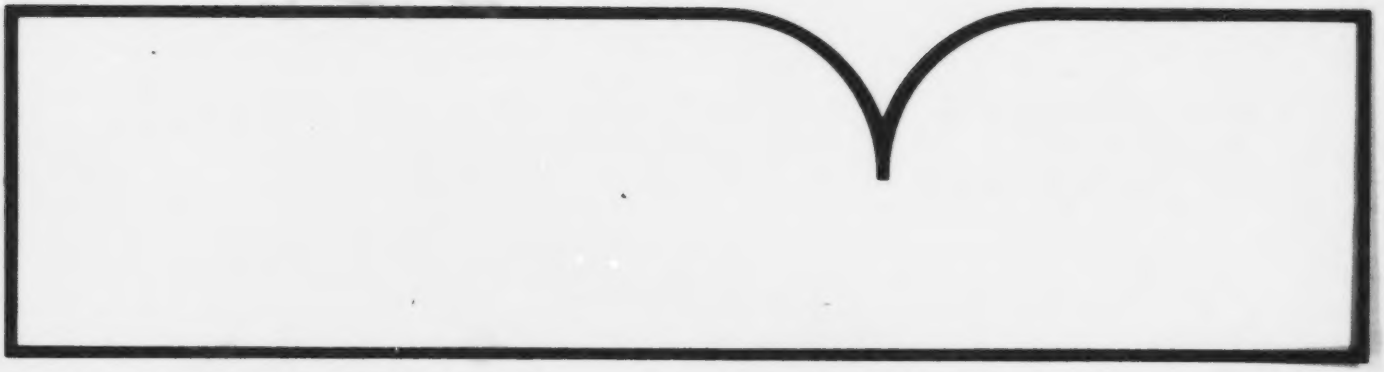

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16. ABSTRACT

A State pollution control agency requested assistance from EPA's Control Technology Center (CTC) in determining possible emission sources within the plant and assessing potential controls for those emissions. This report summarizes the results of a site visit and the review of the plant operations and test reports.

Data gathering involved collection of test reports, permit applications and other information on waferboard manufacturing operations. States where waferboard is manufactured were contacted to establish controls used for various operations. A site inspection was made to examine operations first-hand and to verify controls in-place. In addition, one State office was visited to discuss the extent of complaints, stack tests conducted, and results of emission dispersion modeling.

As the control equipment at the plant has improved since its construction in 1983, complaints have gradually decreased. It appears that substitution of another wood species for aspen which is currently predominantly used would reduce emissions. Another potential option for reduction of emissions is a variation of the dryer operating conditions. Use of a water or caustic scrubber is another potential control mechanism.

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EVALUATION OF EMISSION SOURCES AT A WAFERBOARD MANUFACTURING PLANT

control technology center

CTC

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EVALUATION OF EMISSION SOURCES AT A WAFERBOARD MANUFACTURING PLANT

CONTROL TECHNOLOGY CENTER

SPONSORED BY:

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NOTICE

This report was prepared by Radian Corporation, Research Triangle Park, NC. It has been reviewed for technical accuracy by the Emission Standards and Engineering Division of the Office of Air Quality Planning and Standards, and the Air and Energy Engineering Research Laboratory of the Office of Research and Development, U.S. Environmental Protection Agency, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

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1.0 INTRODUCTION

1.1 SCOPE

The Control Technology Center (CTC) was established by the Environmental Protection Agency (EPA) Office of Research and Development and the Office of Air Quality Planning and Standards to assist State and local air pollution control agencies in the implementation of their air toxics and other pollution control programs. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

This document reports the results of direct engineering assistance provided by the CTC for the State of Colorado. The scope of the assistance was determined by the specific needs of the State, and the findings presented in this report may not be applicable to other facilities and operations which were not visited. Also, control technology presented in this document is not necessarily endorsed by EPA for establishment of the basis for regulations, since the decision of whether or not to regulate a source category and the selection of the technology on which to base regulations are responsibilities of the individual State or local authorities. This document is, however, intended to provide technical information which may assist in making such decisions.

1.2 OVERVIEW

The State of Colorado Department of Health has received complaints of eye and lung irritation from residents near the waferboard manufacturing plant near Olathe, Colorado. The State requested assistance from the CTC in determining possible emission sources within the plant and assessing potential controls for those emissions. This report summarizes the results of a site

visit and the review of the plant operations and test reports. The State of Colorado has also requested an investigation by the National Institute for Occupational Safety and Health (NIOSH).

Several activities have been conducted during the course of this investigation. Data gathering involved collection of test reports, PSD applications and other information on waferboard manufacturing operations. States where waferboard is manufactured were contacted to establish controls used for various operations. A site inspection was made to examine operations first-hand and to verify controls in-place. In addition, the State of Colorado offices were visited to discuss the extent of complaints, the stack tests conducted and the results of modeling.

This report is organized into several sections. After this introduction, Section 2.0 presents waferboard processing in general and some specific data on the Olathe, Colorado, plant. A historical perspective of the complaints about the waferboard plant is given in Section 3.0. The test reports and modeling are discussed in Section 4.0, with Section 5.0 focussing on information on formaldehyde specifically. Finally, Section 6.0 gives the summary of the inspection at the plant. Appendices to the report contain various data gathered during this investigation:

Appendix A	Safety Data on Materials at Olathe Plant
Appendix B	NIOSH P&CAM 125 Method for Formaldehyde
Appendix C	Modeling Results

2.0 PROCESS DESCRIPTION

2.1 WAFERBOARD MANUFACTURING

Waferboard was invented in 1961 as an alternative to plywood and particleboard in the construction industry. Its properties are in many ways superior to particleboard, while being more economical than plywood. Waferboard is comprised of thin, dried wood flakes bonded together with polymeric materials. Phenol-formaldehyde resins were used initially in waferboard manufacture. Other alternatives are used today, primarily methylene bisphenyl isocyanate (MDI).

The first waferboard plant in the United States was built in 1971 in Grand Rapids, Minnesota. Today, the industry has expanded somewhat to include more than 31 operating units in 14 states and provinces in the United States and Canada. Figure 2-1 illustrates the national distribution of waferboard plants. Most plants are situated in remote areas where there is an abundant supply of relatively inexpensive timber. Table 2-1 presents a listing of most waferboard plants with production rates, press and dryer specifications, and particulate matter controls used. Production rates depend upon the number of platens in each press and how many press/dryer trains are in use. While most plants use pine as the primary wood species in production of waferboard, other species such as aspen are also used at varying weight percentages in the product board.

Louisiana-Pacific Corporation operates several waferboard plants in Idaho, Minnesota, Wisconsin, Virginia, Maine and Colorado. The company also plans to construct another plant in California but is currently in litigation over PSD permits. There are two Louisiana-Pacific sites in Colorado, Olathe and Kremmling.

2.2 OLATHE PLANT

On October 23, 1983, Louisiana-Pacific applied for permits to construct a waferboard plant in southern Colorado. These permits were granted on September 17, 1984. The plant was started up in the fall of 1984. As seen in

Figure 2-1. Regional Distribution of Waferboard Plants

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TABLE 2-1. WAFERBOARD PLANTS

Plant/Location	Dryer	Press	Capacity Tons/day	Controls on Wafer Dryer
1. Great Lakes Forest Thunder Bay, Ont.	1 - 1053	8 x 20-10	250	Dropout box + secondary 36" cyclones
2. Temple-Eastex Claremont, NH	1 - 135-62S	4 x 16-16	160	Dropout box + multiclone
3. Northwood Chatham, N.B.	2 - 1242T	8 x 24-11	330	Dropout box + one single secondary cyclone
4. Weldwood Longlac, Ont.	1 - 1038T	4 x 16-24	240	Dropout box + fan skimmer to single cyclone
5. Normac-Peron Lasaire, Que.	1 - 1242T	8 x 16-6	120	Primary single cyclone
6. Potlach Bemidji, MN	4 - 1038T	Unknown	320	Primary single cyclone + secondary multiclone
7. Potlach Cook, MN	4 - 1038T	Unknown	320	Primary single cyclone + secondary multiclone
8. Wafer Board Grandmere, Que.	2 - 1240T	8 x 16-12	240	Primary cyclone for each dryer
9. Georgia-Pacific Woodland, ME	2 - 1250T	8 x 16-16	320	Single cyclone each dryer both connect into same secondary cyclone
10. Grant Waferboard Englehart, Ont.	2 - 1248T	8 x 16-14	280	Primary single cyclone

TABLE 2-1. WAFERBOARD PLANTS (Continued)

Plant/Location	Dryer	Press	Capacity Tons/day	Controls on Wafer Dryer
11. Blandin Wood Grand Rapids, MN	4 - 1240T	8 x 28-6	210	Primary single cyclone + secondary cyclone
12. Weyerhaueser Grayling, MI	4 - 1248T	8 x 24-16	480	Dual primary in parallel + secondary multiclone, EFB
13. Weldwood Slave Lake, Alb.	1 - 1040T	4 x 16-24	240	Primary cyclone only
14. Northwood Bemidji, MN	2 - 1248T	8 x 24-14	420	Dropout box + dual cyclone + dual tertiary cyclones
15. Louisiana-Pacific Houlton, ME	2 - 1248T	8 x 16-12	240	Primary dual cyclones + secondary multiclone
16. Martin LeMoyen, LA	3 - 1250T	8 x 16-16	320	Primary single cyclone on each dryer
17. Waferboard Corp. Timmins, Ont.	1 - 1248T	8 x 16-6	120	Primary single cyclone
18. Panofor Inc. Val D'or, Que.	2 - 1248T	8 x 16-12	240	Primary single cyclone
19. J. M. Huber Co. Easton, ME	2 - 1248T	8 x 16-12	240	Primary single cyclone + 4 secondary cyclones in parallel
20. Pelican Mills Edson, Alb.	2 - 1260T	8 x 24-12	360	Primary single cyclone + secondary multiclone

TABLE 2-1. WAFERBOARD PLANTS (Concluded)

Plant/Location	Dryer	Press	Capacity Tons/day	Controls on Wafer Dryer
21. MacMillan-Bloedel Hudson Bay, Sas.	1 - 1248T	4 x 16-18	180	Primary single cyclone
22. Louisiana-Pacific Chilco, ID	1 - 1260T	8 x 16-8	160	Primary single cyclone + secondary multiclone, EFB
23. Louisiana-Pacific Kremmling, CO	1 - 1260T	8 x 16-8	160	Primary single cyclone + secondary multiclone, EFB
24. Louisiana-Pacific Montrose, CO	1 - 1260T	8 x 16-8	160	Primary single cyclone + secondary multiclone, EFB
25. Louisiana-Pacific Corrigan, TX	2 - 1260T	4 x 16-21	210	Primary single cyclone + secondary multiclones
26. Louisiana-Pacific Urania, LA	1 - 1260T	4 x 16-18	180	Primary single cyclone + secondary multiclone
27. Louisiana-Pacific Two Harbors, MN	1 - 1260T	8 x 16-8	160	Primary single cyclone + secondary multiclone
28. Georgia-Pacific Grenada, MS	4 - 1260T	8 x 24-16	480	Primary single cyclone + secondary multiclone
29. Highland Forest Inverness, Scotland	1 - 1260T	8 x 16-8	160	Primary single cyclone + secondary multiclone
30. McMillan-Bloedel Thunderbay, Ont.	2 - 1260T	4 x 24-16	240	Primary single cyclone + secondary multiclone

Figure 2-2, the Louisiana-Pacific site is near Olathe, Colorado, near Highway 50 just inside the Montrose County line. The plant is a net consumer of water. There are no discharges to the Uncompahgre River nearby. Unlike other waferboard plants that use primarily pine, the Olathe facility uses aspen cut from the local private lands.

2.2.1 Process Operations

The waferboard process at the Olathe plant is similar to other facilities except in the amount of aspen used in wafer production. At Olathe, aspen is used almost exclusively. The plant uses a single train process with one triple-pass dryer and a single press line. As seen in Table 2-1, the Olathe plant is a relatively small waferboard facility, producing approximately 160 tons per day.

Figure 2-3 presents the basic flow diagram for the waferboard process at the Olathe plant. Trees are trucked to the facility and maintained in the stockpile area. The logs are cut using a slasher saw to approximately 100 inches in length and then placed into hot ponds. Hot ponds are maintained at between 80 and 100^{o}F and are used to pre-treat logs prior to waferizing, particularly during the winter when logs are frozen. From hot ponds, the logs are moved into the mill where they are debarked and trimmed in fixed slasher saws to 33 inches. Bark and slasher saw trims are used in the Konus energy recovery system.

The short logs are sliced into thin wafers (i.e., waferized) about 1-1/2 by 3 inches, and 0.028 inch thick. The wet wafers are stored in an intermediate bin before being fed to the rotary dryer. The 12-foot diameter drum dryer is 60 feet long and employs three passes to dry the wafers from about 30-40 percent moisture to 4-10 percent, depending on the resin used in bonding the wafers into a board. Dry wafers are collected using a cyclone and further classified in a rotary drum screen. Sized dry wafers are stored in a bin for use in the board line. Fines from the dryer are used to fuel the dryer.

The wafer dryer has never operated above the nominal design capacity of 96,000 tons per year (based on 4 percent moisture). Hourly adjustments are made to regulate dryer operation. The McConnel burner on the dryer uses a constant air-to-fuel ratio based on the 4.6 lbs of fuel (undersized dry

Figure 2-2. Site in Colorado

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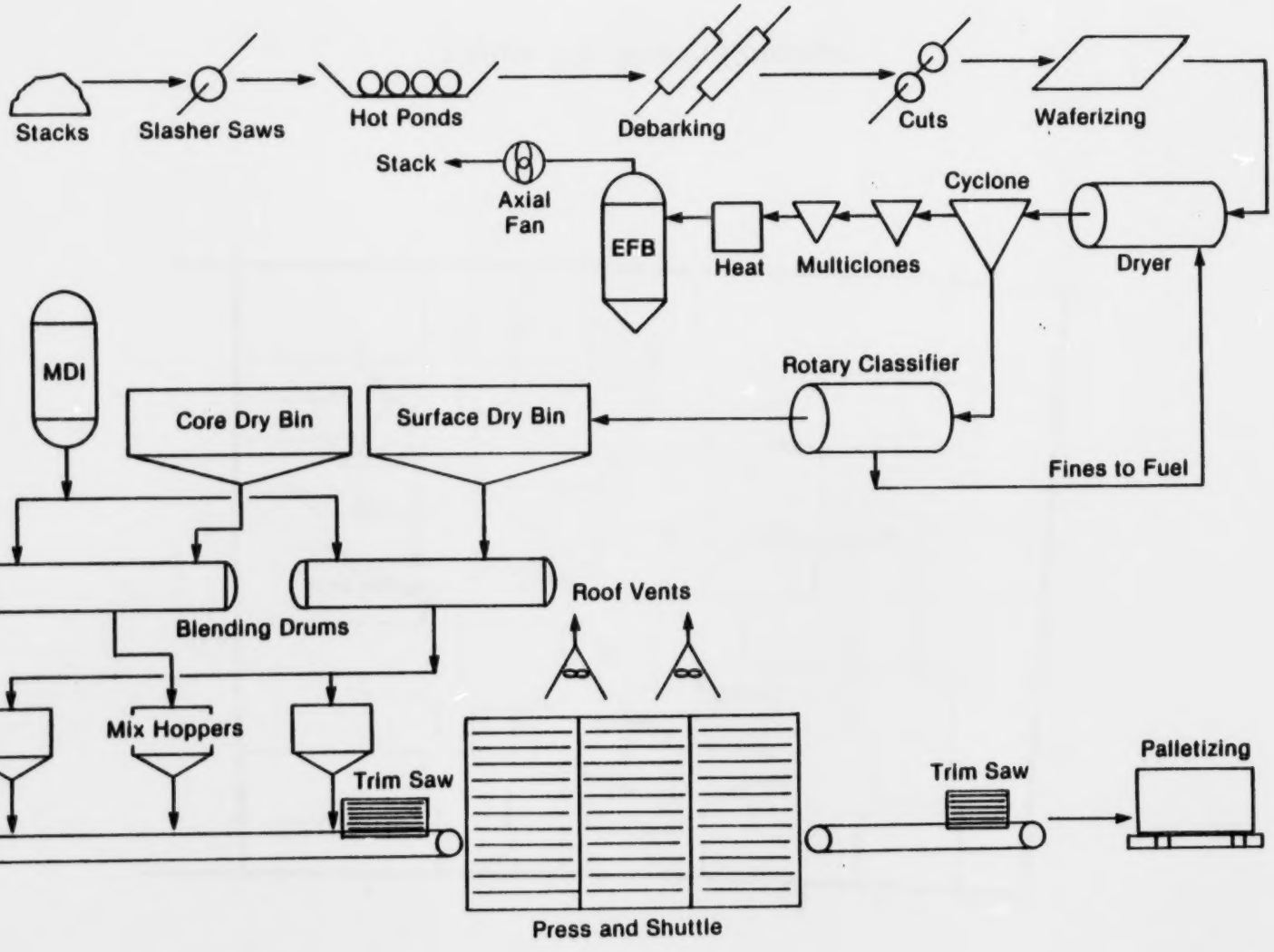


Figure 2-3. Waferboard Process Flow Diagram

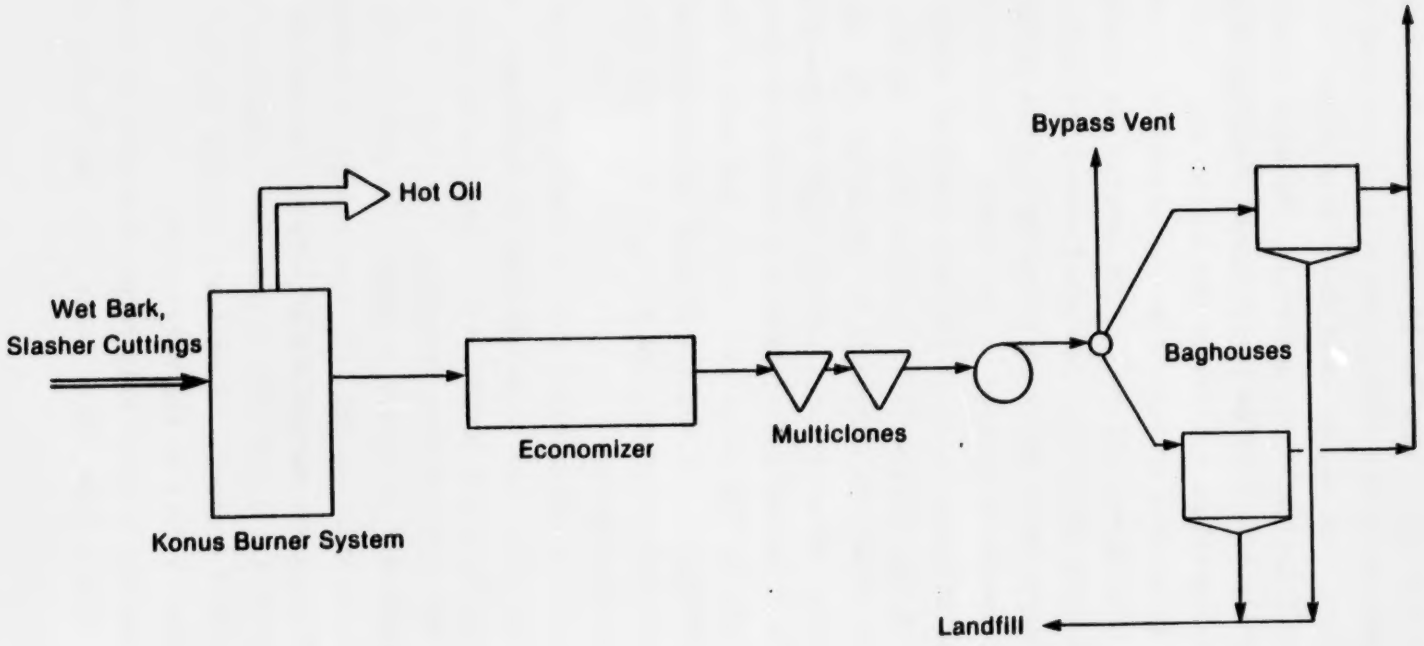
wafers) per revolution on the rotary feeders from the undersize collection bin to the burner. Diesel fuel (No. 1 and No. 2) can be used as a back-up to the dry material during start-up of the dryer. The bulk of the dryer air does not enter through the burner. Even so, an inlet dryer temperature of up to 1,750°F (1,100 to 1,600°F typically) is achieved. The mass throughput of the dryer does not necessarily affect wafer temperature. Removing moisture from the wafers yields a high moisture content of the outlet gas. As a result, the dryer air is unsuited to be used as combustion air elsewhere in the facility.

Two blenders are used to mix MDI resin with wafers; one blender for core material and one for surface material. Resinated wafers are sent to bins above formers on the board line. Prior to spreading out the bottom surface layer,a mold release compound is sprayed on the screen. Then as the screen moves toward the press, the core layer of the waferboard is spread on the bottom surface layer. A top surface layer is added next. Surface layers are placed independently to allow some alignment of the wafers for improvement of appearance and properties. After the top surface layer of the material is placed on the screen, a different top surface mold release is sprayed onto the board. Over 1,500 pounds per day of release agents are used in the Olathe waferboard plant. According to the results of some laboratory testing by the State of Colorado, some heavy aldehydes are released from the thermal decomposition of the release agents.

Sixteen-foot sections or mats, eight feet in width, are roughly formed by trimming with a traveling saw. Saw trims are used to supplement the fuel to the rotary dryer. Formed mats are accumulated in the loader; when all eight panels are ready they are shuttled into the press.

The press forms eight 8 x 16 panels at once. The press cycle varies with the board thickness. When pressing the 7/16-inch boards, a 4 minute 8 second cycle time is used. Platens are maintained at between 185 and 200°C. Pressed panels are shuttled out of the press into an unloader. Each panel is trimmed and cut to produce four 4 x 8 sheets. Panels are stacked and palletized for shipment. Trims are used as fuel in the wafer dryer.

The Olathe plant employs a Konus heat recovery system as shown in Figure 2-4. Bark and sawdust from slasher cuts fuel the firebox of the Konus



Note: Hot oil provides heat to the press, tanks, buildings, and hot ponds.

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Figure 2-4. Flow Diagram of Konus Hot Oil System

system. The burner operates at high excess air levels to ensure complete combustion. An automatic damper controls the pressure to 1 inch H_2O to maintain optimum conditions. Heat from the firebox and economizer is transferred to a hot oil system. Hot oil supplies the heat requirements of many operations throughout the plant. Hot oil is used in the hot ponds, in process tanks, and in the press. The hot oil system also provides building heat in the winter.

2.2.2 Emissions Controls

As with the industry, the emission controls at the Olathe waferboard plant have been designed to abate particulate matter emissions and visible emissions or opacity. At Olathe, the two press vents are uncontrolled. The press is shrouded by siding material. Steam and any other press emissions are drawn out of the enclosure by two roof-mounted axial exhaust fans. The fans discharge at roof level.

The wafer dryer and the Konus system are both controlled for particulate matter and opacity. As mentioned earlier, the Konus system burns bark and dust from slasher saws to produce heat used throughout the facility. Emissions are controlled using a series of multiclones followed by two parallel baghouses. Konus has provided such systems for other waferboard and wood processing operations. Early in production, the Olathe plant experienced fires in the baghouses caused by burning embers not caught in the multiclones. The carryover of embers to the baghouses was due to a shift in particle size distribution from that expected by Konus engineers. This may have been the result of the high percentage of aspen used at Olathe compared to pine at other facilities. Modifications to the existing system have corrected this particular problem.

The wafer dryer uses a number of control measures to reduce particulate matter emissions and opacity. The measures taken have brought the source into compliance with both particulate matter process weight rate and opacity requirements of the State of Colorado. Table 2-2 traces the history of emissions control improvement for the wafer dryer. The current control includes 1) a primary cyclone to remove product wafers, 2) secondary multiclones to reduce particulate matter emissions further, 3) in-duct burner

TABLE 2-2. CHRONOLOGY OF WAFER DRYER EMISSIONS CONTROLS

Date	Device (Addition)	Comment
xx/84	Cyclone/multiclone	Did not meet particulate matter Did not meet opacity
10/85	EFB/increased stack height	Did not meet opacity Met particulate matter
6/86	Axial fan in stack	Improved ionizer reliability
11/86	In-duct burner before EFB	Met opacity
2/87	Voltage controls for EFB	Improved control of individual beds

to raise gas temperature, 4) electrified filter bed to reduce particulate matter emissions below grain loading requirements, and 5) an axial fan to improve ionizer performance.

2.2.3 Other Controls

As part of the investigation, agencies at States where waferboard plants are operating were contacted to determine the controls in use. In addition, the latest supplements of the BACT/LAER Clearinghouse were reviewed to determine what, if any, control technology determinations have been made for waferboard plants. The controls used throughout the industry were designed for particulate matter reductions. Controls at veneer plants were also considered. For example, one veneer plant in Oregon uses a wet ESP to control predominantly visible emissions (opacity). Organic emissions were not the issue in developing the control strategy.

The contacts made included Minnesota, Maine, Louisiana and the Canadian province of Ontario. In terms of coverage, these four contacts represented 15 operating units. In Minnesota, multiclones and electrified fluid beds (EFB's) are used. One scrubber is also in use. Tall stacks were recommended to meet the State concentration requirements of 1 percent of the TLV concentrations. Only one unit in Minnesota has nearby neighbors. In Maine, all units are relatively isolated. No states have requested tests to quantify formaldehyde emissions. Also, there has been no experience with odor-related problems. The controls and BACT determinations have focused on particulate matter and opacity abatement. The facilities in Louisiana are also isolated. While there have been no complaints against them, the facilities have had trouble with particulate matter emissions. As in the United States, the emphasis in Canada is on particulate matter emissions. According to local contacts, there has been no real source testing.

A review of the Control Technology Determinations from the BACT/LAER Clearinghouse showed again the emphasis on particulate matter and visible emissions (opacity) from waferboard plants. Three determinations have been made relative to the dryer and combustion sources:

J. M. Huber Company	Easton, ME
Louisiana-Pacific Corporation	Houlton, ME
Georgia-Pacific Corporation	Dudley, NC

The controls comprising these BACT determinations consist of high efficiency cyclones and cyclones combined with an ESP. Up to 99.92 percent efficiency for reducing particulate matter emissions as high as 99.9 percent have been established as BACT for a wafer dryer. The basis of this high efficiency was not reported.

3.0 COMPLAINTS

The State of Colorado states that since the plant was constructed there have been complaints concerning the plant's operation. The Olathe waferboard plant is in a sparsely populated district. The area is open giving good visibility for long distances. There are no other industrial manufacturing facilities in the immediate vicinity.

The first complaints were received by the State in September 1984, when the plant started up. During the first two years, perhaps five to six calls were received monthly. The complaints appeared to increase with the publicity given to the problem. As the control equipment was improved, the complaints gradually decreased. However, in the more recent past, residents close to the plant have been complaining up to six times per month. There are no obvious patterns to complaints. State personnel observed that perhaps most complaints come during the winter months (November to March) when the cold weather adversely impacts the downwash from the stacks.

The initial complaints concerned particulate emissions. There was a clearly evident plume from the wafer dryer stack and, during the initial operation of the plant, the controls on the Konus heat recovery system experienced several breakdowns. The Konus system employs multiclones and baghouses to control emissions. Initially, some burning particles were not collected in the multiclones, resulting in fires in the baghouses. During this period, the baghouses were often bypassed, resulting in a dark smoke plume. Konus engineers corrected the particle sizing from the firebox. Now, the only smoke emitted from the Konus system is during startups and unexpected, uncontrolled shutdowns. One such incident was observed during the site investigation. The majority of the smoke stopped after approximately one hour.

There have been several improvements to the particulate matter control system on the wafer dryer stack. Photographs taken during the initial operation showed a dark visible plume trailing miles into the distance. A primary cyclone and multiclones were designed to reduce particulate matter

below the required levels but failed to meet the State's requirements. The electrified filter bed (EFB) added in October 1985 reduced the grain loading sufficiently to meet the regulations, but it was not until November 1986 that the opacity was reduced to below the regulated level. This was done by adding an axial fan to improve ionizer efficiency and an in-duct burner to increase stack temperature.

Complaints of eye and lung irritation have persisted since the plant started up. The odors have been characterized as burning, acrid aromas. The local State agent describes the odor as having a sweet, astringent quality. The residents who have issued complaints have seen medical personnel regarding the complaints, but as of the date of the site investigation no doctors have cited the plant as the cause of the irritations. The State has conducted some ambient sampling, but the results have been inconclusive.

Finally, there continue to be complaints of noise from the plant. In late 1984, the State received the first complaints of smog (smoke from the Konus system) and noise. This area is relatively free of industry and thus the plant does contribute more to the noise of the area. Since the terrain is open, sound carries great distances. This could be contributing to the complaints of noise.

4.0 TEST REPORTS AND MODELING

4.1 EMISSION TESTS

Two series of emissions tests have been conducted by Interpoll Inc. (Circle Pines, Minnesota), at the Olathe waferboard plant in Colorado: 12-14 March 1985 and 18-20 June 1986. Both series of tests involved the major sources at the facility: the Konus system, the wafer dryer and the two press vents. The pollutants of concern included particulate matter, total non-methane VOC, and certain specific compounds (formaldehyde, MDI, HCN, phenol). For combustion sources (i.e., Konus burner and McConnel burner of the wafer dryer), other criteria pollutants (CO, NO_x, SO_2) were also measured that demonstrated proper combustion efficiency. Since the focus of the complaints is eye and lung irritation, only emissions of VOC and toxics such as formaldehyde will be addressed in this section.

Table 4-1 presents the results of the most recent organic emissions tests at the Olathe plant. The highest concentration of VOC emissions is produced by the wafer dryer. The difference between the wafer dryer and press emissions is noted in the evaluation of formaldehyde emissions. As shown in Table 4-1, the formaldehyde concentration from the wafer dryer is two orders of magnitude greater than press emissions. It is recommended, however, that additional testing be conducted to determine the species emitted from the press. The total organic emissions from this source are of equal magnitude to the wafer dryer and the decomposition products of the release agents may be heavy aldehydes. Determination of the specific species emitted is important since, based on modeling results, the nearest homes are most likely impacted by press emissions.

Emissions of MDI were determined using NIOSH Method P&CAM 142. NIOSH methods measure concentrations of gases related to ambient or workplace air. All of the results of MDI testing at the Olathe plant were at or below the detection limit of the method. As a result, the actual concentration of MDI is unknown. The conservative assumption is that all concentrations are

TABLE 4-1. VOC TEST RESULTS: JUNE 1986[a]

Pollutant	Wafer Dryer		East Press Vent		West Press Vent	
	ppm	g/s	ppm	g/s	ppm	g/s
VOC	420	2.53	120	1.15	240	1.73
Formaldehyde	71.5	1.08	0.65	0.016	1.1	0.019
MDI	<0.01	<0.002	<0.01	<0.003	<0.01	<0.002

[a]Data taken during operation of plant after conversion to MDI resin.
[b]Concentration in ppm as CH_4.
[c]Concentration in ppm, dry.

equivalent to the detection limit. Actual concentrations are at or below these tabulated values.

Formaldehyde was measured using NIOSH Method P&CAM 125. The analytical technique is visible absorption spectrophotometry. This method, given in Appendix B, uses impingers to collect the sample. Color is developed using a chromotropic acid/sulfuric acid solution and the working range is 0.02 to 0.4 ppm in air. A similar method was used in early EPA studies of emissions from air oxidation processes (including the manufacture of formaldehyde). More recently, however, EPA has been considering ion chromatography and high-pressure liquid chromatography (HPLC) as better methods for formaldehyde. There are no EPA reference methods for formaldehyde in stack gases.

Formaldehyde emissions from the wafer dryer are compared for two sets of conditions. In Table 4-2, the results of the two sets of dryer tests are given, with some pertinent process data. The second test has almost twice the formaldehyde emissions as the test from the previous year. Along with the higher mass throughput in the June 1986 test, there is an associated increase in gas flow rate. The exit moisture content of both gas and wafer are lower than in the early test, and the outlet gas temperature was reduced, either through the higher gas flow rate or the increased transfer of heat to the wafers. An important result of the comparison of these tests is the obvious change in emission rate. This indicates a potential for reducing formaldehyde emissions through control of wafer dryer operating conditions. Some laboratory testing of particle drying included in Appendix D shows there may be potential control of formaldehyde emissions through variation of drying temperature and time. Another possible alternative to controlling formaldehyde emissions suggested by this laboratory work is the use of different wood species. This laboratory paper is discussed in Section 5.0 on formaldehyde.

4.2 ISCST MODEL RESULTS

The 1981 version of the Industrial Source Complex Short Term (ISCST) model was used by the Colorado Department of Health to estimate the impacts of particulate matter, formaldehyde and MDI emissions from the Olathe plant.

TABLE 4-2. COMPARISON OF DRYER TESTS

	March 1985	June 1986
Total non-methane organics, ppm CH_4	413	420
Formaldehyde, ppm (dry)	45	71
Formaldehyde, lb/hr	4.4	8.6
Gas Stream		
Flow rate, acfm	42,700	47,700
Water content, % volume	23.8	17.0
Stack temperature, °F	234	212
Inlet temperature, °F	1,160	1,130
Outlet temperature, °F	261	244
Wafer		
Feed belt speed, %	50	67
Inlet moisture, %	46.6	ND
Outlet moisture, %	5.9	3.7
Production Rate, tons/day	N/A	N/A

ND = Not Determined
N/A = Not Available

Data inputs used in the modeling effort came from the most recent testing at the plant. The meteorological data were for the five-year period 1977 through 1981 sited at Grand Junction, Colorado. Grand Junction and Olathe lie in two different troughs where prevailing air movements are oriented differently. To accommodate this difference, the wind rose was effectively rotated to implement the Grand Junction meteorological data at the Olathe site.

The complete results of the modeling are given in Appendix C, along with a summary memorandum by Alan Dresser of the Colorado Department of Health. The modeling results have been reviewed and appear to be valid. The pollutant of concern is formaldehyde. The modeling results show that a maximum 1-hour concentration of 62 ug/m^3 is possible in the vicinity of the plant. Figure 4-1 shows the plant and the location of the maximum average concentration receptors. The 8-hour and 24-hour maximum average concentrations for formaldehyde, both above 15 ug/m^3, occur at this same receptor.

Examining the maximum formaldehyde concentration, the majority of the impact results from the wafer dryer. The press vents contribute only 0.8 ug/m^3 to the total maximum concentration. For MDI concentrations, 90 percent of the modeled impact is related to the press vents. It is important to note, however, the model used the results of the latest tests which were values at the detection limit of the analytical method. The MDI values, therefore, do not necessarily represent actual emissions measurements.

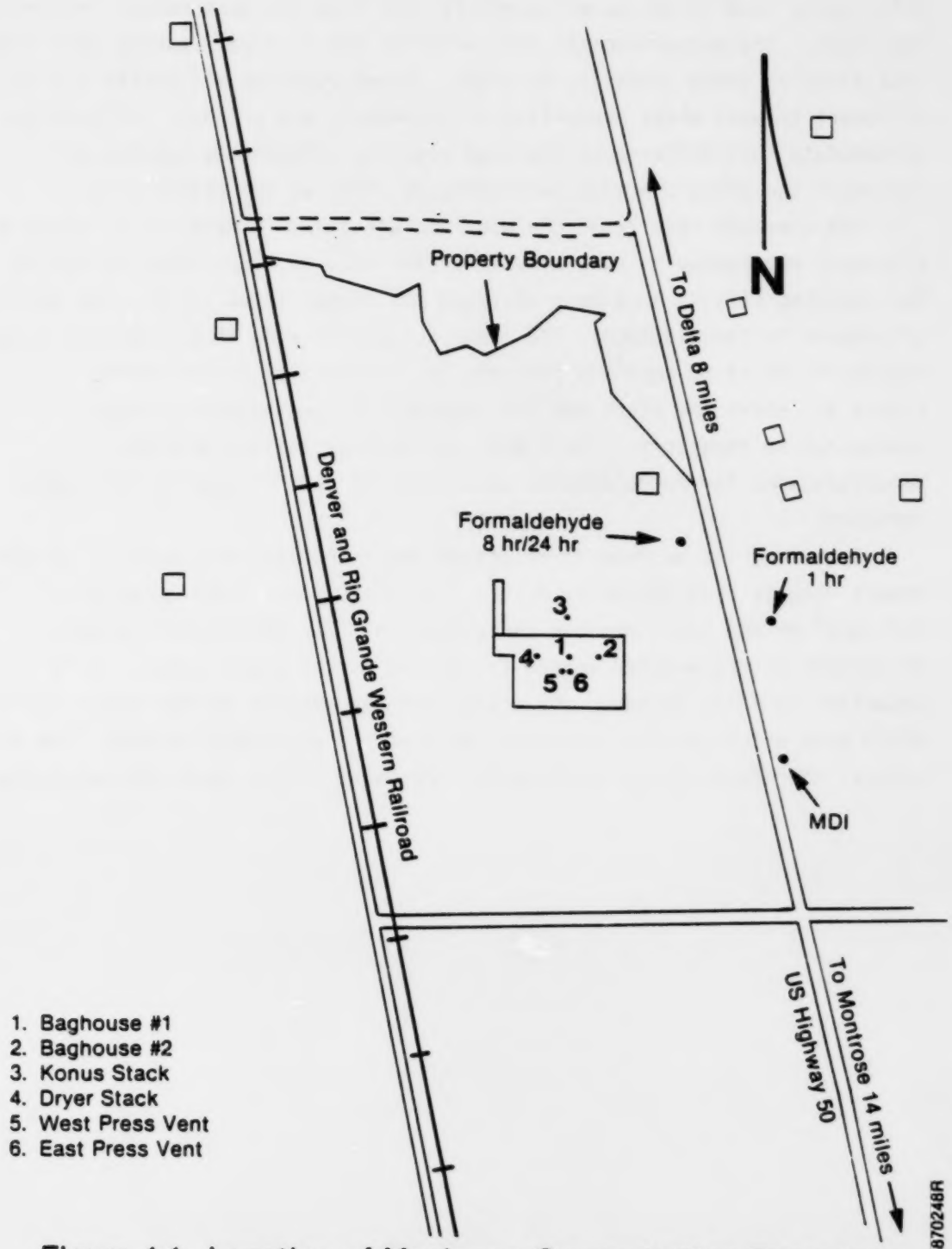

Figure 4-1. Location of Maximum Concentration Receptors

5.0 FORMALDEHYDE

From the preceding section, emissions of formaldehyde are noted as the largest VOC constituent identified that has a local impact. At the Olathe plant, there are three potential sources of formaldehyde emissions: the Konus burner, the press vents and the wafer dryer. Both combustion sources (Konus burner and McConnel burner) operate efficiently, leaving little potential for formaldehyde emissions. The resin change from phenol-formaldehyde to MDI should result in lower overall formaldehyde emissions. Furthermore, during the site visit there were no noticeable odors in the gases vented from the press area. The wafer dryer, however, has the highest emissions of formaldehyde of any of the sources considering both source tests.

Wood decomposition has been a traditional source of organic chemicals. For example, the main source of methanol was formerly destructive distillation of wood. Likewise, wood decomposition can yield other organic compounds such as acetic acid and formaldehyde. In 1928, Freudenberg identified formaldehyde as a by-product of wood hydrolysis. And by 1947, Kratzl found formaldehyde was released in the alkaline hydrolysis of spruce lignin sulfonates. Formaldehyde can also be evolved from the polysaccharides in the thermolysis of wood. Acids naturally present in the wood convert the polysaccharides to oxymethylfurfural, an unstable compound which decomposes to formaldehyde and furfural. The transformation is promoted by the separation of aliphatic acids (especially acetic acid) from the wood. In addition, formaldehyde can also be produced from methanol in the wood decomposition process.

In a paper by Marutsky and Roffael, formaldehyde emissions from wood drying are examined. Test data on drying three types of wood using two techniques were gathered and compared. Pine, spruce and beech were studied using pressing and jet-tube drying. Jet-tube drying is most analogous to the wafer drying operation at Olathe.

The jet-tube dryer operated with an entry temperature of 536^{o}F and an exit temperature of 284^{o}F. Wood chips were dried to a final moisture content of 3 to 4 percent. Table 5-1 presents the results of these tests with an

TABLE 5-1. RESULTS OF JET-TUBE DRYER TESTS

Wood Type	Moisture Content, %		Formaldehyde Concentration	
	Before	After	mg/m^3 (STP)	ppm, dry*
Beech	31	4	4.8	5.6
Spruce	32	3	5.9	6.9
Pine	50	4	6.5	7.6

*Concentrations estimated using 842 ppm = 1 mg/liter.

Note: Reference article included in Appendix D.

approximated ppm value for comparison to the Olathe tests. The results show that formaldehyde emissions vary with the type of wood being dried. The thermal conditions during the laboratory studies were not as severe as those encountered in the Olathe wafer dryer. This might account for the significantly lower emissions.

Data from the press drying show remarkable increases in formaldehyde emissions with temperature. For beech drying, there is a four- to six-fold increase in the amount of formaldehyde released when the platen temperature is raised from 160^{o}C to 220^{o}C. The other woods showed similar, though less dramatic, increases. These results indicate 1) the potential for large increases in emissions with temperature and with time, 2) the potential for emissions from waferboard press operations, and 3) the potential for reduction of wafer dryer emissions by varying operating conditions.

The article provided insufficient information to generate an emission factor to compare these tests with the Olathe results. The translated article was provided to the Colorado agency under separate cover.

6.0 SUMMARY OF INSPECTION

The waferboard facility at Olathe, Colorado, was inspected on 8 April 1987. The operations, emissions and controls at the facility were reviewed with plant personnel, a corporate environmental contact and State agency representatives. The physical plant was inspected while the plant was running to observe normal plant practices.

The facility is a clean operation, even considering its age. The entire process is well conceived mechanically and sufficiently instrumented to provide good fundamental process control. The process is largely enclosed, but must be accessed directly at times. Paraffin wax is added to the MDI/wafer mix transferred to the forming hoppers. This operation involves opening the enclosed conveyor belt to pour the paraffin wax onto the resin/wafer mix. The highest potential exposure to MDI emissions in the plant occur during this operation. Operators use breathing air lines when conveyors are opened each hour to apply the gallon or more of the wax material to the MDI/wafer mix on the transfer belts.

The facility uses MDI as the polymer binder for the wood wafers. According to the U. S. Department of Health and Human Services, MDI is a known irritant. (See Appendix A.) The facility has had three complaints in the last year from workers in the blender area. These systems are now enclosed and there have been no complaints in the last two months. Louisiana-Pacific has conducted an in-house health and safety audit of the entire facility, but the results have not been released. As an added note, the substitution of MDI for phenol-formaldehyde resins has reduced fugitive dust emissions in the plant.

In Section 2.0, the emissions controls were discussed. The focus of these controls has been on particulate matter and opacity, since these are the only regulated pollutants. The facility now employs controls that achieve compliance with the particulate matter and opacity regulations. The question of VOC, predominantly aldehyde, control has been examined by Louisiana-Pacific's environmental contact. Various techniques have been considered, including bubble cap column, packed column, and venturi scrubbers. These techniques are effective in removing aldehydes from the vent streams,

but they may not be effective on all VOC constituents vented. Furthermore, while these techniques may be technically feasible in removing some VOC from vent gases, there may be structural constraints on installing a scrubber on the roof of the manufacturing building near the stacks. Another potential problem associated with wet scrubbing at this site is the availability of water and treatment of wastewater for discharge. The facility currently does not have any water discharges and additional permitting would be required. The absorbed aldehydes, particularly formaldehyde, would create polluted water effluents which may be unacceptable for the site. Further treatment may be possible, however. For example, the undesired pollutant could potentially be stripped from scrubbing fluid and then incinerated. This approach involves additional processing and equipment and, therefore, may not be practical when considering costs.

Other VOC control altenatives include carbon adsorption and condensation. Louisiana-Pacific investigated the potential for using carbon adsorption. Manufacturers could not recommend a reasonable carbon adsorption system, but did recommend wet scrubbing or incineration. Because the vented gases are relatively high volume, low concentration streams, these other classical VOC control techniques are also difficult and costly to apply.

Possible control alternatives for the dryer are not evident from a review of existing controls at other waferboard facilities. Based on the examination of formaldehyde test results on three types of wood, perhaps substitution of raw material (that is, change of wood species) would reduce emissions. Another option indicated by test results is variation of dryer operating conditions. Changing dryer conditions appeared to shift emissions during the two tests at the Olathe facility, althoug reductions based on these changes have not been completely verified or quantified. Use of a water scrubber is another possible control alternative. Formaldehyde is readily absorbed into water, but the water would have to be treated before discharge to the nearest surface waters. Water is a valuable resource in Colorado and its use as a scrubbing fluid creates another issue in the State.

Caustic scrubbers have been successfully used to reduce formaldehyde emissions from other industrial sources. The formaldehyde reacts rapidly with the caustic to form sodium formate, reducing formaldehyde concentrations in

air to near zero concentrations. The sodium formate solution must be treated in a wastewater treatment system before discharge to surface waters or municipal systems. The scrubber solution could alternately be disposed of by incineration. This would permit use of a closed scrubber system with periodic removal of contaminated solution.

APPENDIX A

SAFETY DATA ON MATERIALS AT OLATHE PLANT

0618

FORMALDEHYDE SOLUTION, 37%
FORMALDEHYDE SOLUTION, 37%
FORMALDEHYDE SOLUTION, 37%

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
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FAIR LAWN NJ 07410
(201) 796-7100

EMERGENCY CONTACTS
GASTON L. PILLORI
(201) 796-7100

DATE: 04/19/86
PO NBR: N/A
ACCT: 681055-01
INDEX: N/A
CAT NO: F79

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SUBSTANCE IDENTIFICATION

CAS-NUMBER 50-00-0

SUBSTANCE: **FORMALDEHYDE SOLUTION, 37%**

TRADE NAMES/SYNONYMS: FORMALIN; FORMIC ALDEHYDE; FORMOL; METHANAL; METHYL ALDEHYDE; METHYLENE GLYCOL;METHYLENE OXIDE; TETRAOXYMETHYLENE; OXOMETHANE; OXYMETHYLENE; F-79; F-79-P

CHEMICAL FAMILY:
ALDEHYDE, ALIPHATIC

MOLECULAR FORMULA: C-H2-O MOL WT: 30.03

CERCLA RATINGS (SCALE 0-3): HEALTH=2 FIRE=2 REACTIVITY=0 PERSISTENCE=0

COMPONENTS AND CONTAMINANTS

PERCENT: 37 COMPONENT: FORMALDEHYDE

PERCENT: 15 COMPONENT: METHANOL

PERCENT: 48 COMPONENT: WATER

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
FORMALDEHYDE: 3 PPM OSHA CEILING;
2 PPM ACGIH CEILING (BUT SEE NOTICE OF INTENDED CHANGE TO 1 PPM WITH ADDITION OF SUSPECT HUMAN CARCINOGEN RATING)

PHYSICAL DATA

DESCRIPTION: COLORLESS LIQUID WITH A PUNGENT ODOR.

BOILING POINT: 214 F (101 C) SPECIFIC GRAVITY: 1.08 PH: 2.8 - 4.0

SOLUBILITY IN WATER: MISCIBLE

SOLVENT SOLUBILITY: SOLUBLE IN ALCOHOL, AND ACETONE ODOR THRESHOLD: 1.0 PPM

VAPOR DENSITY: 1.04

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
MODERATE FIRE AND EXPLOSION HAZARD WHEN EXPOSED TO HEAT OR FLAME.

VAPOR-AIR MIXTURES ARE EXPLOSIVE ABOVE FLASH POINT.

REACTION OF FORMALDEHYDE WITH NITROGEN DIOXIDE, NITROMETHANE, PERCHLORIC ACID AND ANILINE, OR PEROXYFORMIC ACID YIELDS EXPLOSIVE COMPOUNDS.

FLASH POINT: 130 F (54 C) UPPER EXPLOSION LIMIT: 73%

LOWER EXPLOSION LIMIT: 7% AUTOIGNITION TEMP.: 806 F (430 C)

FLAMMABILITY CLASS(OSHA): II

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY OR FOAM
(1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR ALCOHOL FOAM
(1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

FIREFIGHTING:
MOVE CONTAINER FROM FIRE AREA IF POSSIBLE. DO NOT GET WATER INSIDE CONTAINER. COOL FIRE-EXPOSED CONTAINERS WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. WITHDRAW IMMEDIATELY IN CASE OF RISING SOUND FROM VENTING SAFETY DEVICE OR ANY DISCOLORATION OF STORAGE TANK DUE TO FIRE (1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

EXTINGUISH ONLY IF FLOW CAN BE STOPPED; USE WATER IN FLOODING AMOUNTS AS FOG, SOLID STREAMS MAY NOT BE EFFECTIVE. COOL CONTAINERS WITH FLOODING QUNATITIES OF WATER; APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING HAZARDOUS VAPORS OR DUSTS, KEEP UPWIND (BUREAU OF EXPLOSIVES, EMERGENCY HANDLING OF HAZARDOUS MATERIALS IN SURFACE TRANSPORTATION, 1981).

ALCOHOL FOAM (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIAL, EIGHTH EDITION).

STOP FLOW OF GAS (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIAL, EIGHTH EDITION).

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101:
ORM-A

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND 172.402:
NONE

TOXICITY

36 MG/KG ORAL-WOMAN LDLO; 8 PPM INHALATION-HUMAN TCLO; 800 MG/KG ORAL-RAT LD50; 590 MG/KG INHALATION-RAT LC50; 270 MG/KG SKIN-RABBIT LD50; MUTAGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS); DEFINITE ANIMAL CARCINOGEN (IARC); INDEFINITE HUMAN CARCINOGEN (IARC, NTP). FORMALDEHYDE HAS CAUSED SQUAMOS CELL CARCINOMAS OF THE NASAL CAVATIES IN RATS. THE EVIDENCE FOR CARCINOGENICITY IN HUMANS IS INADEQUATE.

FORMALDEHYDE IS AN EYE, MUCOUS MEMBRANE, AND SKIN IRRITANT. IT IS ALSO A SKIN AND RESPIRATORY SENSITIZER.

HEALTH EFFECTS AND FIRST AID

INHALATION:
TOXIC/IRRITANT. 100 PPM (FORMALDEHYDE) IMMEDIATELY DANGEROUS TO LIFE OR HEALTH

ACUTE EXPOSURE- FORMALDEHYDE IN VAPORS OR MIST AT CONCENTRATIONS OF 1 PPM CAUSE MUCOUS MEMBRANE AND RESPIRATORY TRACT IRRITATION WITH TEARING AND MILD TINGLING SENSATIONS IN THE NOSE AND THROAT. HIGH CONCENTRATIONS MAY CAUSE COUGH, HEADACHE, NAUSEA, WEAKNESS, PALPITATION, DYSPNEA, BURNING OF THE NOSE AND THROAT, BRONCHITIS, PULMONARY EDEMA, PNEUMONITIS AND DEATH.

CHRONIC EXPOSURE- MAY CAUSE MUCOUS MEMBRANE IRRITATION. THERE IS EVIDENCE THAT SUGGESTS THAT CHRONIC FORMALDEHYDE INHALATION MAY PROMOTE THE FORMATION OF SQUAMOUS CELL NASAL CARCINOMAS, AND MAY CAUSE CIRRHOSIS OF THE LIVER AND CHRONIC HEART DISEASE. SEE HUMAN AND ANIMAL CARCINOGENIC AND ANIMAL MUTAGENIC, REPRODUCTIVE EFFECTS, AND TUMORIGENIC REFERENCES IN TOXICITY SECTION. FORMALDEHYDE CAUSES RESPIRATORY TRACT SENSITIZATION.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP AFFECTED PERSON WARM AND AT REST. GET MEDICAL ATTENTION.

SKIN CONTACT:
IRRITANT.

ACUTE EXPOSURE- MAY CAUSE IRRITATION. SENSITIZATION DERMATITIS MAY OCCUR IN PREVIOUSLY EXPOSED WORKERS. LESIONS MAY OCCUR DUE TO A SUDDEN ECZEMATOUS REACTION ON THE EYELIDS, FACE, NECK, SCROTUM, AND FLEXOR SURFACE OF THE WHICH MAY COME ONLY A FEW DAYS AFTER EXPOSURE. ECZEMATOUS REACTIONS MAY ALSO OCCUR AFTER A NUMBER OF YEARS ON THE HANDS, WRISTS, FOREARMS, AND PARTS OF THE BODY THAT ARE EXPOSED TO FRICTION FROM CLOTHING. SHRINKING OF THE MUCOUS MEMBRANES, AND NECROSIS MAY OCCUR.

CHRONIC EXPOSURE- REPEATED OR PROLONGED CONTACT MAY CAUSE HARDENING AND CRACKING OF THE SKIN, AND SENSITIZATION DERMATITIS.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION.

EYE CONTACT:
IRRITANT.
ACUTE EXPOSURE- FORMALDEHYDE VAPORS OR MISTS MAY CAUSE IRRITATION AND MILD LACRIMATION. CONCENTRATIONS OF 10 PPM CAN BE WITHSTOOD FOR ONLY A FEW MINUTES AND CAUSES PROFUSE LACRIMATION IN ALL SUBJECTS. OCCULAR DAMAGE HAS BEEN STATED TO RESULT WITH EXPOSURE TO FORMALDEHYDE VAPORS. SOLUTIONS OF 25-44% SPLASHED IN THE EYES MAY CAUSE BURNS, SEVERE INJURY AND CORNEAL DAMAGE.

CHRONIC EXPOSURE- MAY CAUSE CONJUNCTIVITIS.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION.

INGESTION:
TOXIC/IRRITANT.
ACUTE EXPOSURE- MAY CAUSE BURNING IN THE MOUTH AND ESOPHAGUS, NAUSEA AND VOMITING, SEVERE ABDOMINAL PAIN, DIARRHEA, VERTIGO, ANURIA, UNCONSCIOUSNESS, JAUNDICE, ALBUMINURIA, HEMATURIA, ACIDOSIS,AND CONVULSIONS. LIVER AND KIDNEY DAMAGE MAY OCCUR. DEATH OCCURS FROM CIRCULATORY FAILURE. A MEAN FATAL DOSE IS ABOUT 2 OUNCES (60 76) OF 37% SOLUTION.

FIRST AID- IF VICTIM IS CONSCIOUS AND NOT CONVULSIVE, IMMEDIATELY GIVE 2 TO 4 GLASSES OF WATER, AND INDUCE VOMITING BY TOUCHING FINGER TO BACK OF THROAT. FROM SITTING POSITION, HEAD MUST BE LOWER THAN HIPS TO PREVENT ASPIRATION. KEEP PATIENT WARM AND AT REST. GET MEDICAL ATTENTION IMMEDIATELY.

REACTIVITY

REACTIVITY:
STABLE AT ORDINARY PRESSURES UP TO THE BOILING POINT, 101 C. A POWERFUL REDUCING AGENT, ESPECIALLY IN THE PRESCENCE OF ALKALI. REACTS VIOLENTLY WITH STRONG OXIDIZERS. REACTS WITH HYDROCHLORIC ACID FORMING BIS(CHLOROMETHYL) ETHER, A POTENT CARCINOGEN.

INCOMPATIBILITIES:
FORMALDEHYDE
NITROMETHANE: FORMS EXPLOSIVE COMPOUND.
PEROXYFORMIC ACID: FORMS EXPLOSIVE COMPOUND.
MAGNESIUM CARBONATE: EXPLOSIVE REACTION DUE TO PRESSURE INCREASE.
NITROGEN DIOXIDE: EXPLOSIVE REACTION IN THE REGION OF 180 C.
HYDROGEN PEROXIDE: VIOLENT REACTION.
STRONG OXIDIZERS: VIOLENT REACTION.
HYDROCHLORIC ACID: FORMS HIGHLY TOXIC BIS(CHLOROMETHYL) ETHER.

DECOMPOSITION:
COMBUSTION MAY RELEASE TOXIC OXIDES OF CARBON.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION WIL NOT OCCUR FOR THE MATERIAL WITHOUT A COPOLYMER.

****

CONDITIONS TO AVOID

MAY BE IGNITED BY HEAT OR FLAMES. CONTAINER MAY EXPLODE IN HEAT OF FIRE. VAPOR EXPLOSION HAZARD INDOORS.

****

SPILL AND LEAK PROCEDURES

OCCUPATIONAL SPILL:
SHUT OFF IGNITION SOURCES. PROVIDE VENTILATION AND WEAR PROTECTIVE EQUIPMENT. DO NOT TOUCH SPILLED MATERIAL. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. FOR SMALL SPILLS TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. CLOSE CONTAINERS AND LABEL "COMBUSTIBLE AND CANCER HAZARD". FOR LARGER SPILLS, DIKE AS CLOSE TO THE SOURCE OF THE SPILL AS IS PRACTICAL AND EFFECTIVE IN ORDER TO REDUCE THE AREA CONTAMINATED AND THE AMOUNT OF MATERIAL SPILLED. NO SMOKING, FLAMES OR FLARES IN HAZARD AREA. KEEP UNNECESSARY PEOPLE AWAY; ISOLATE HAZARD AREA AND DENY ENTRY. KEEP OUT OF SEWERS AND WATER SOURCES.

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST VENTILATION SYSTEM TO MEET PERMISSIBLE EXPOSURE LIMITS.

RESPIRATOR:
EXPOSURE LIMIT TO 30 PPM- CHEMICAL CARTRIDGE RESPIRATOR WITH AN ACID GAS CARTRIDGE AND A FULL FACEPIECE.
GAS MASK WITH AN ACID GAS CANISTER (CHIN-STYLE, FRONT-, OR BACK-MOUNTED CANISTER).
SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.

> 30 PPM INCLUDING IDLH CONCENTRATION TO 100 PPM- TYPE 'C' SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE OR CONTINUOUS FLOW MODE.

FIREFIGHTING- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
WEAR IMPERVIOUS CLOTHING IF THERE IS REASONABLE PROBABILITY OF CONTACT WITH SOLUTION.

GLOVES:
WEAR IMPERVIOUS GLOVES IF THERE IS REASONABLE PROBABILITY OF CONTACT WITH SOLUTION.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-PROOF SAFETY GOGGLES TO PREVENT THIS SUBSTANCE FROM CONTACTING THE EYES. DO NOT WEAR CONTACT LENSES WHEN WORKING WITH CHEMICALS.

AUTHORIZED - ALLIED FISHER SCIENTIFIC

CREATION DATE: 01/14/85 REVISION DATE: 08/13/85

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SURFACTANTS, INC.

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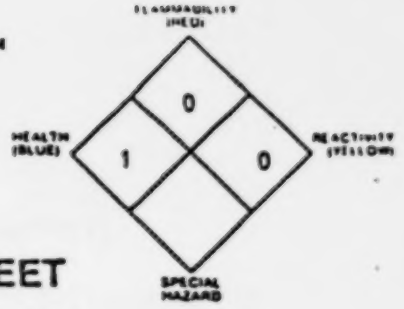
(201) 549-3151

NFPA Designation 704

DEGREE OF HAZARD
4 = EXTREME
3 = HIGH
2 = MODERATE
1 = SLIGHT
0 = INSIGNIFICANT



MATERIAL SAFETY DATA SHEET

Section 1. Identity of Material

PRODUCT NAME OR NUMBER	"R.C.-40"
SYNONYMS	Mold Release
FORMULA	Proprietary
CAS NUMBER	None
CHEMICAL FAMILY	
REGULATED IDENTIFICATION — DOT PROPER SHIPPING NAME	
SHIPPING ID NUMBER / UN / NA	EPA HAZARDOUS WASTE ID NUMBER

HAZARDOUS INGREDIENTS	%	TLV UNITS	CAS NUMBER
This material contains no hazardous chemicals			
as established by the Hazard Communication			
Standard (29CFR1910.1200)			

Section 2. Hazard Specifications

KNOWN HAZARDS UNDER 29 CFR 1910.1200	YES	NO		YES	NO
COMBUSTIBLE LIQUID		X	SKIN HAZARD		X
FLAMMABLE MATERIAL		X	EYE HAZARD	X	
PYROPHORIC MATERIAL		X	TOXIC AGENT		X
EXPLOSIVE MATERIAL		X	HIGHLY TOXIC AGENT		X
UNSTABLE MATERIAL		X	SENSITIZER		X
WATER REACTIVE MATERIAL		X	CARCINOGEN		X
OXIDIZER		X	REPRODUCTIVE TOXIN		X
ORGANIC PEROXIDE		X	BLOOD TOXIN		X
CORROSIVE MATERIAL		X	NERVOUS SYSTEM TOXIN		X
COMPRESSED GAS		X	LUNG TOXIN		X
IRRITANT		X	LIVER TOXIN		X
			KIDNEY TOXIN		X

TLV* None established

PEL* None established

NFPA HAZARD SIGNAL

HEALTH	1	FLAMMABILITY	0
STABILITY	0	SPECIAL	

DOT HAZARD CLASS

Not regulated

EPA HAZARD WASTE CLASS

Not a hazardous waste under RCRA

Section 3. Safe Usage Data

PROTECTIVE EQUIPMENT TYPES	EYES	Chemical safety goggles if splash conditions prevail (or face shield & glasses)
	RESPIRATORY	None indicated
	GLOVES	None indicated
	OTHER	None
VENTILATION	GENERAL MECHANICAL	Not required
	LOCAL EXHAUST	Not required
PRECAUTIONS	HANDLING & STORAGE	No special precautions. Store in cool dry place for quality assurance.
	OTHER	Protect from freezing.

Section 4. Emergency Response Data

FIRE	EXTINGUISHING MEDIA: Not flammable or combustible
	SPECIAL PROCEDURES: None
	UNUSUAL HAZARDS: None
EXPOSURE	FIRST AID MEASURES: Eyes - wash with water for 15 minutes. Get medical aid if irritation persists.
SPILLS	STEPS TO BE TAKEN: Mop up and water washdown. Sewer drain - biodegradable detergent.
RQ =	WASTE DISPOSAL METHOD: Check any federal, state & local regulations.

Section 5. Physical Hazard Data

FLAMMABILITY	LFL = N/A % UFL = %		FLASH POINT METHOD USED None	°F °C
STABILITY	STABLE	X	CONDITIONS TO AVOID: Freezing	
	UNSTABLE		HAZARDOUS DECOMP PDTS	
HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID: None known	
	WILL NOT OCCUR	X		
INCOMPATIBILITY	MATERIALS TO AVOID: Acids			

Section 6. Health Hazard Data

EFFECTS OF EXPOSURE	Possible eye irritation if this product splashes.
EMERGENCY TREATMENT	Eyes - wash with water for 15 minutes. Get medical aid if irritation persists.

Section 7. Physical and Chemical Properties

BOILING PT = 212 °F °C	VAPOR DENSITY (AIR=1) N/A	VOLATILE COMPONENTS Water vapor
VAPOR PRESS = Water mmHg @	pH 1% solution 9.5 - 10.5	
SOLUBILITY IN H_2O Complete	WILL DISSOLVE IN Water	EVAPORATION RATE (=1) same as water
APPEARANCE Available as amber or opalescent green liquid		IS MATERIAL: GAS
ODOR Mild detergent fragrance		SOLID LIQUID X GAS

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U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME: SURFACTANTS, INC.	EMERGENCY TELEPHONE NO.
ADDRESS (Number, Street, City, State and ZIP Code): 48 LIBERTY STREET, METUCHEN, NJ 08840	
CHEMICAL NAME AND SYNONYMS: N.A. - COMPOUNDED PRODUCT	TRADE NAME AND SYNONYMS: AGENT R - 40
CHEMICAL FAMILY: N.A. - COMPOUNDED PRODUCT	FORMULA: N.A.-COMPOUNDED PRODUCT

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS NONE			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
NONE		

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	NEAR 212°F	SPECIFIC GRAVITY (H_2O=1)	0.92
VAPOR PRESSURE (mm Hg.)	SIMILAR TO WATER	PERCENT, VOLATILE BY VOLUME (%)	62-64%
VAPOR DENSITY (Air=1)	NOT AVAILABLE	EVAPORATION RATE (WATER = 1)	APPROX 1.0
SOLUBILITY IN WATER	DISPERSES IN ALL PROPORTIONS		
APPEARANCE AND ODOR	HEAVY BODIED OPAQUE WHITE LIQUID-BLAND ODOR		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)	ABOVE 200°F(C.C.)	FLAMMABLE LIMITS	LEL: N/A; UEL: N/A
EXTINGUISHING MEDIA	CAN SAFELY EXTINGUISH FIRES IN AREA WITH WATER, WATER FOG, CO$_2$ and AND DRY CHEMICAL		
SPECIAL FIRE FIGHTING PROCEDURES	NONE REQUIRED		
UNUSUAL FIRE AND EXPLOSION HAZARDS	none		

PAGE (1)

(Continued on reverse side)

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SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
NOT HAZARDOUS

EFFECTS OF OVEREXPOSURE
NOT HAZARDOUS, BUT MIST WILL CAUSE IRRITATION OF MUCOUS SURFACES-

EMERGENCY AND FIRST AID PROCEDURES
IF SPLASHED IN EYES, FLUSH WITH MUCH WATER

SECTION VI - REACTIVITY DATA

STABILITY			CONDITIONS TO AVOID
	UNSTABLE		
	STABLE	XX	NONE

INCOMPATABILITY (Materials to avoid)
DO NOT MIX WITH ACIDS

HAZARDOUS DECOMPOSITION PRODUCTS
THERMAL DECOMPOSITION MAY GENERATE CARBON DIOXIDE OR CARBON MONOXIDE

HAZARDOUS POLYMERIZATION			CONDITIONS TO AVOID
	MAY OCCUR		
	WILL NOT OCCUR	XX	NONE

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
SMALL AMOUNTS CAN SAFELY BE RUN INTO SEWAGE SYSTEM LARGE AMOUNTS SHOULD BE ABSORBED IN SAWDUST OR CLAY AND SHOVELED INTO DRUMS

WASTE DISPOSAL METHOD
REMOVE DRUMS OF SAWDUST (ETC) TO APPROVED LANDFILL OR INCINERATE

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type)
SPRAY ONLY IN WELL VENTILATED AREAS OR USE "FUME HOOD"

VENTILATION			
	LOCAL EXHAUST	ADEQUATE	SPECIAL NONE
	MECHANICAL (General)		OTHER

PROTECTIVE GLOVES
NOT NORMALLY NEEDED

EYE PROTECTION
NOT NORMALLY NEEDED

OTHER PROTECTIVE EQUIPMENT
NONE REQUIRED

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
KEEP FROM FREEZING

OTHER PRECAUTIONS
NO COMPONENTS OF THIS PRODUCT LISTED AS HAZARDOUS BY IARC NOR ARE THEY OSHA REGULATED

GPO 878-146
Form OSHA-20
Rev. May 72

Jim Walter research corp.
10301 NINTH STREET NORTH
ST. PETERSBURG, FLORIDA 33702
(813) 576-4171
Contact: Dr. E. K. Moss

ER - 350

PRODUCT IDENTIFICATION

NAME: ER - 350

CHEMICAL NAME/SYNONYM: PROPRIETARY EMULSION IN WATER

CHEMICAL FAMILY: MIXTURE FORMULA: N/A

C.A.S. NUMBER: MIXTURE D.O.T. HAZARD CLASS ID. NO: NONE

D.O.T. SHIPPING NAME: NONE

LABEL REQUIREMENTS: DOT: NONE

WARNINGS AND PRECAUTIONS

THIS PRODUCT DOES NOT CONTAIN ANY HAZARDOUS COMPONENTS.

HAZARDOUS INGREDIENTS

INGREDIENT	C.A.S. NO.	%	HAZARD	EXPOSURE LIMITS

ISSUE DATE: November 11, 1986

REVISION DATE: None

EMERGENCY AND FIRST AID PROCEDURES

EYE CONTACT: Flush with water for 15 minutes. Get medical aid.

SKIN CONTACT: Wash with soap and water.

INHALATION: Move to fresh air.

INGESTION: Get medical aid.

PHYSICAL DATA

APPEARANCE: Tan liquid emulsion

BOILING POINT: 212°F MELTING POINT: ND pH (5%) 6.0 - 8.0

SPECIFIC GRAVITY: 0.98 gm/ml @ 77°F VAPOR PRESSURE: N.D.

SOLUBILITY IN WATER: Dispersible

OTHER: None

FIRE AND EXPLOSION

FLASH POINT: Above 200°F METHOD: PMCC

NFPA DESIGNATION: HEALTH: 1 FIRE: 1 REACTIVITY: 0

FLAMMABLE LIMITS: LEL: N.D. UEL: N.D.

EXTINGUISHING MEDIA: Carbon Dioxide, Foam

SPECIAL FIREFIGHTING PROCEDURES: Use NIOSH approved respirators and protective clothing.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

OCCUPATIONAL CONTROL

EYE PROTECTION: Safety glasses. Eye bath available.

SKIN PROTECTION: Gloves. Safety shower available.

RESPIRATORY PROTECTION: Organic vapor canister mask in vapors concentrations.

VENTILATION: General (mechanical) ventilation satisfactory.

HEALTH DATA

HUMAN EXPOSURE: Primary routes of exposure are eue and skin contact. ACUTE OVEREXPOSURE: EYE - May cause inflammation. SKIN - Prolonged contact may cause inflammation. INHALATION: No Data. INGESTION: May cause vomiting.

TOXICITY: It has not been determined if exposure to this product aggravates any existing medical conditions or if there are any target organ effects.

REACTIVITY

STABILITY: Stable **HAZARDOUS POLYMERIZATION:** No

MATERIALS TO AVOID: Strong reducing agents or Alkali.

CONDITIONS TO AVOID: None

HAZARDOUS DECOMPOSITION PRODUCTS: (Thermal) NO_x, CO_x

SPILL OR LEAK PROCEDURES

ACTION IN CASE OF RELEASE OR SPILL: Contain spill. Soak up with absorbant materials and remove to containers for disposal.

WASTE DISPOSAL METHOD: Dispose of in accordance with local, state and federal EPA regulations.

Occupational Health Guideline for Methylene Bisphenyl Isocyanate (MDI)

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $NCOC_6H_4CH_2C_6H_4NCO$
- Synonyms: MDI; 4,4-diphenylmethane diisocyanate; methylene bis (4-phenyl isocyanate); 4,4-diisocyantodiphenylmethane
- Appearance and odor: White to light-yellow flakes with no odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methylene bisphenyl isocyanate is a ceiling level of 0.02 part of methylene bisphenyl isocyanate per million parts of air (ppm). This may also be expressed as 0.2 milligram of methylene bisphenyl isocyanate per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Methylene bisphenyl isocyanate can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Exposure to methylene bisphenyl isocyanate may make a person allergic to it and produce wheezing, shortness of breath, and coughing. It may also cause irritation of the eyes and lungs, upset stomach, vomiting, possibly fever, stuffiness of the nose, sore throat, a feeling of tightness in the chest, cough, shortness of breath and wheezing. Such symptoms may be delayed up to eight hours after the person has been exposed.

2. Long-term Exposure: A person may become increasingly sensitive or allergic to methylene bisphenyl isocyanate. Chronic exposure to it may lead to permanent breathing or chest problems. Repeated or prolonged exposure of the skin to methylene bisphenyl isocyanate may cause a skin rash.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methylene bisphenyl isocyanate.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to methylene bisphenyl isocyanate at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of asthma, allergies, or known sensitization to methylene bisphenyl isocyanate would be expected to be at increased risk from exposure. Examination of the eyes and respiratory tract should be stressed.

—14" x 17" chest roentgenogram: Methylene bisphenyl isocyanate may cause lung damage in humans. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Methylene bisphenyl isocyanate is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is considered necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease.

- **Summary of toxicology**

Methylene bisphenyl isocyanate (MDI) vapor is a potent respiratory sensitizer. It also is a strong irritant of the eyes, mucous membranes, and skin and can cause

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

pulmonary edema. Exposure of humans to high concentrations causes cough, dyspnea, increased secretions, and chest pain. Isocyanates cause pulmonary sensitization in susceptible individuals; should this occur, further exposure should be avoided, since extremely low levels of exposure may trigger an asthmatic episode; cross sensitization to unrelated materials probably does not occur. The liquid in contact with the eye may cause an irritation.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 250.25
2. Boiling point (760 mm Hg): 172 C (341.6 F)
3. Specific gravity (water = 1): 1.27
4. Vapor density (air = 1 at boiling point of methylene bisphenyl isocyanate): 8.6
5. Melting point: 37 C (98.6 F)
6. Vapor pressure at 20 C (68 F): 0.05 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.2
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: Temperatures above 37.8 C (100 F)
2. Incompatibilities: Avoid contact with strong alkalies, acids, and alcohol.
3. Hazardous decomposition products: Toxic gases and vapors (such as oxides of nitrogen and carbon monoxide) may be released in a fire involving methylene bisphenyl isocyanate.
4. Special precautions: Liquid methylene bisphenyl isocyanate will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: 202 C (395.6 F) (open cup)
2. Autoignition temperature: 240 C (464 F)
3. Flammable limits in air, % by volume: Not applicable
4. Extinguishant: Carbon dioxide, dry chemical, or inert gas. For large fires, water in the form of spray should be used.

- **Warning properties**

1; Odor Threshold: No quantitative information is available.

2; Irritation Levels: By analogy to TDI, which, according to Grant, causes irritation of the eyes and nose beginning at 0.05 ppm to 0.1 ppm, MDI is assumed to produce eye and nose irritation at the same levels.

3; Evaluation of Warning Properties: MDI is treated as a material with poor warning properties, for the purposes of this guideline. By analogy with TDI, MDI is assumed to produce eye and nose irritation within several times the permissible exposure limit, but the permissible exposure is a ceiling concentration.

MONITORING AND MEASUREMENT PROCEDURES

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methylene bisphenyl isocyanate. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

At the time of publication of this guideline, no measurement method for methylene bisphenyl isocyanate had been published by NIOSH.

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with solid methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate, where skin contact may occur.
- If employees' clothing may have become contaminated with methylene bisphenyl isocyanate, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing contaminated with methylene bisphenyl isocyanate should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of methylene bisphenyl isocyanate from

the clothing. If the clothing is to be laundered or otherwise cleaned to remove the methylene bisphenyl isocyanate, the person performing the operation should be informed of methylene bisphenyl isocyanate's hazardous properties.

• Non-impervious clothing which becomes contaminated with methylene bisphenyl isocyanate should be removed promptly and not reworn until the methylene bisphenyl isocyanate is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate contacting the eyes.

SANITATION

• Skin that becomes wet with methylene bisphenyl isocyanate should be promptly washed or showered with soap or mild detergent and water to remove any methylene bisphenyl isocyanate.

• Employees who handle solid methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methylene bisphenyl isocyanate may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during in place spraying of urethane foams	Local exhaust ventilation; respiratory protective equipment
Liberation during in place molding of urethane foams	Local exhaust ventilation; dilution ventilation
Liberation during application of polyisocyanate lacquer sealant finishes	Local exhaust ventilation; respiratory protective equipment
Liberation during shake-out and core knock-out operations at foundries using MDI-oil-base-no-bake binding systems	Local exhaust ventilation; respiratory protective equipment
Liberation during manufacture of lacquer	Process enclosure; local exhaust ventilation
Liberation during production of component chemicals for foam systems	Local exhaust ventilation; process enclosure
Liberation during casting of high-density polyurethane elastomers	Process enclosure; local exhaust ventilation
Liberation following combustion of urethane foams in fires or thermal decomposition to salvage metal inserts	Air-supply respiratory protective equipment or local exhaust ventilation
Liberation of unreacted vapor during cutting and fabricating of polyurethane foams	Local exhaust ventilation; respiratory protective equipment
Liberation during curing process; during flame lamination of fabrics	Process enclosure; local ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate soak through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention promptly.

• **Breathing**

If a person breathes in large amounts of methylene bisphenyl isocyanate, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When methylene bisphenyl isocyanate or liquids containing methylene bisphenyl isocyanate have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify some-

one else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If methylene bisphenyl isocyanate is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.

2. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

• Waste disposal methods:

Methylene bisphenyl isocyanate may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

2. By atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Methylene Bisphenyl Isocyanate," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Toluene-2,4-Diisocyanate," *Hygienic Guide Series*, Detroit, Michigan, 1967.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.

• Key, M. M.: "Occupational Dermatitis from Plastics," *Journal of Medicine of the Association of Georgia*, 57:421-424, September 1968.

• Konzen, R. B., et al.: "Human Response to Low Concentrations of p, p-Diphenylmethane Diisocyanate (MDI)," *American Industrial Hygiene Association Journal*, 27:121-127, 1966.

• Lapp, N. L.: "Physical Changes in Diagnostic Aids in Isocyanate Exposure," *American Industrial Hygiene Association Journal*, 32:378-382, 1971.

• National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Toluene Diisocyanate*, HSM 73-11022, U.S. Government Printing Office, Washington, D.C., 1973.

• Rye, W. A.: "Human Responses to Isocyanate Exposure," *Journal of Occupational Medicine*, 15:306-307, 197

• Woolrich, P. F., and Rye, W. A.: "Urethanes - Engineering, Medical Control and Toxicologic Considerations," *Journal of Occupational Medicine*, 11:184-190, 1969.

RESPIRATORY PROTECTION FOR METHYLENE BISPHENYL ISOCYANATE (MDI)

Condition	Minimum Respiratory Protection* Required Above 0.02 ppm
Vapor or Particulate Concentration	
1 ppm (10 mg/m³) or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10 ppm (100 mg/m³) or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 10 ppm (100 mg/m³) or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

APPENDIX B

NIOSH P&CAM 125
METHOD FOR FORMALDEHYDE

FORMULA: $H_2C{=}O$; CH_2O

M.W. = 30.03

FORMALDEHYDE

METHOD: 3500
ISSUED: 2/15/84

OSHA: 3 ppm; C 5 ppm; P 10 ppm
NIOSH: lowest feasible level [1]
ACGIH: C 2 ppm
(1 ppm = 1.23 mg/m³ @ NTP

PROPERTIES: gas; BP -19.5 °C;
vapor density 1.067 (air = 1.00);
explosive range 7 to 73 % v/v in air

SYNONYMS: methanal; CAS #50-00-0; formalin (aqueous 30 to 50% w/v HCHO).

SAMPLING

SAMPLER: FILTER + IMPINGERS
(1-µm PTFE membrane and 2 impingers, each with 20 mL 1% sodium bisulfite solution)

FLOW RATE: 0.2 to 1 L/min

VOL-MIN: 2 L @ 1 ppm
-MAX: 100 L

SHIPMENT: transfer samples to bottles before shipping

SAMPLE STABILITY: 30 days @ 25 °C

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 100 to 600 µg per sample [2]

BIAS: none identified

OVERALL PRECISION (s_r): 0.09 [2]

MEASUREMENT

TECHNIQUE: VISIBLE ABSORPTION SPECTROPHOTOMETRY

ANALYTE: formaldehyde

SAMPLE WORKUP: note liquid volume; remove 4-mL aliquot

ANALYSIS: color development (chromotropic acid + sulfuric acid); absorbance @ 580 nm

CALIBRATION: solutions of formaldehyde in distilled water

RANGE: 2 to 40 µg per sample

ESTIMATED LOD: 0.5 µg per sample [2,3]

PRECISION (s_r): 0.03 [2]

APPLICABILITY: The working range is 0.02 to 0.4 ppm (0.025 to 0.5 mg/m³) for an 80-L air sample. This is the most sensitive formaldehyde method in the NIOSH Manual of Analytical Methods and is able to measure ceiling levels as low as 0.1 ppm (15-L sample). It is also preferred for the determination of formaldehyde in area samples at all concentrations due to its simplicity.

INTERFERENCES: Phenols, in 8-fold excess over formaldehyde, produce a -10% to -20% bias [4]. Ethanol and higher M.W. alcohols, olefins, aromatic hydrocarbons [5] and cyclohexanone also produce small negative interferences [4]. Little interference is seen from other aldehydes [4].

OTHER METHODS: This method was originally adapted from the Intersociety Committee [6] and designated P&CAM 125 [4]. For personal samples or where interferences to this method are present, use Method 2502.

REAGENTS:

1. Chromotropic acid, 1%. Dilute 0.10 g 4,5-dihydroxy-2,7-naphthalene disulfonic acid disodium salt to 10 mL with distilled water. Filter. Store in brown bottle. Prepare fresh weekly.
2. Sulfuric acid, 96%.*
3. Formaldehyde stock solution, 1 mg/mL (See APPENDIX).
4. Formalin solution, 37%.*
5. Distilled, deionized water.
6. Sulfuric acid, 0.02 N, aqueous.
7. Sodium hydroxide, 0.01 N, aqueous.
8. Sodium sulfite, 1.13 N, aqueous.
9. Sodium bisulfite, 1%. Dissolve 1 g in distilled water. Dilute to 100 mL. Prepare fresh weekly.

*See Special Precautions.

EQUIPMENT:

1. Sampler: 37-mm filter cassette with 37-mm polytetrafluoroethylene (PTFE) membrane filter, 1- to 3-μm pore size followed by two midget impingers; inert, flexible tubing for cassette-to-impinger connection.
2. Personal sampling pump, 0.2 to 1 L/min, with flexible connecting tubing.
3. Bottles, screw-cap Nalgene CPE, 50-mL.
4. Spectrophotometer, visible, 580 nm.
5. Volumetric pipettes, 0.1-, 0.5-, 1-, 4-, 5-, 6- and 10-mL; 1-, 2- and 5-mL, graduated in 0.1-mL units, with pipet bulb.
6. Volumetric flasks, 10- and 100-mL, and 1-L.
7. Burets, 50-mL.
8. pH meter.
9. Pipettes, 2-mL, disposable, with pipet bulb.
10. Spectrophotometer cuvettes, 1-cm.
11. Flasks, glass-stoppered, 25-mL.
12. Graduated cylinder, 25-mL.
13. Waterbath at 95 °C.
14. Magnetic stirrer.
15. Beaker, 50-mL.

SPECIAL PRECAUTIONS: Sulfuric acid is extremely corrosive; handle while wearing acid-resistant gloves, apron and full face shield with goggles.

Formaldehyde is viewed as a potential carcinogen by NIOSH [1] and should be handled in a hood.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Fill the two impingers for each sample with 20 mL 1% sodium bisulfite solution. Make cassette-to-impinger and impinger-to-sampling pump conections with flexible, inert tubing. Insert a second filter/cassette assembly in line between the sampler and sampling pump to trap any liquid which might splash over from the impingers during sampling.
3. Sample at an accurately known flow rate between 0.2 and 1 L/min for a total sample size of 2 to 100 L.
4. Transfer the contents of the impingers to separate polyethylene bottles for shipping.

SAMPLE PREPARATION:

5. Transfer each impinger solution to a clean, dry 25-mL graduated cylinder. Note volume of solution from front impinger, V_f (mL), backup impinger, V_b (mL), and blank impinger, V_B (mL).
6. Pipette 4-mL aliquots from each sample solution into 25-mL glass-stoppered flasks.
   NOTE: Adjust aliquot size to contain between 2 and 20 μg formaldehyde for optimum absorbance.

CALIBRATION AND QUALITY CONTROL:

7. Prepare a calibration stock solution by dilution of 1 mL of 1 mg/mL formaldehyde stock solution to 100 mL with 1% sodium bisulfite solution.
8. Pipet, e.g., 0, 0.1, 0.3, 0.5, 0.7, 1.0 and 2.0 mL calibration stock solution into 25-mL glass-stoppered flasks.
9. Add 1% sodium bisulfite solution to bring the volume of each working standard to 4 mL.
   NOTE: These working standards contain approximately 0, 1, 3, 5, 7, 10, and 20 µg formaldehyde. Use the exact values based on standardization of the formaldehyde stock solution.
10. Analyze together with samples and blanks (steps 12 through 15.
11. Prepare calibration graph (absorbance vs. µg formaldehyde/4 mL).

MEASUREMENT:

12. Add 0.1 mL 1% chromotropic acid to the flask and mix.
13. Add 6 mL conc. H_2SO_4 slowly to the flask. Replace the stopper gently. Gently swirl the solution to mix.
    CAUTION: Exothermic reaction.
14. Heat the solution to 95 °C for 15 min. Cool the solution to room temperature.
    NOTE: Use caution due to the corrosive nature of hot sulfuric acid and the possible pressure buildup within the flask.
15. Read sample absorbance at 580 nm in a 1-cm cuvette.
    NOTE: If absorbance is greater than the highest standard, take a smaller aliquot, dilute to 4 mL with 1% sodium bisulfite solution, and analyze.

CALCULATIONS:

16. Calculate the mass, µg, of formaldehyde in each front impinger (M_f), back impinger (M_b) and average blank impinger (M_B). Use the appropriate aliquot factor (e.g., 4 mL aliquot/original volume from step 6) and the total sample volume noted in step 5.
    NOTE: Discard the sample if the mass found in the backup impinger exceeds 1/3 the mass found in the front impinger. Collection efficiency is <0.95 for each impinger.
17. Calculate the concentration, C (mg/m^3), of formaldehyde in the air volume sampled, V (L):

$$C = \frac{M_f + M_b - 2M_B}{V}, \ mg/m^3$$

EVALUATION OF THE METHOD:

The method was checked for reproducibility by having three different analysts in three different laboratories analyze standard samples containing between 1 and 20 µg formaldehyde. The results agreed within ± 5% [6]. This method was independently compared with the 2,4,-dinitrophenylhydrazine-coated silica gel method of Beasley et al. over the range of 0.8 to 2.2 ppm formaldehyde [8] and was found to give approximately 25% lower concentrations. In another study comparing this method, P&CAM 318 [7], and the method of Beasley, et al., all three methods were found to be statistically equivalent under laboratory test conditions and loadings from 8.2 to 22.4 µg per sample of formaldehyde [9].

REFERENCES:
[1] NIOSH Current Intelligence Bulletin 34, "Formaldehyde: Evidence of Carcinogenicity," U.S. Department of Health and Human Services, Publ. (NIOSH) (NIOSH) Publication No. 81-111 (1981).
[2] Formaldehyde, No. S327 Failure Report, NIOSH/OSHA Standards Completion Program Contract Report (1976).
[3] User check, Southern Research Institute, NIOSH Sequence #3500 (unpublished, November 10, 1983).
[4] NIOSH Manual of Analytical Methods, 2nd ed., V.1, P&CAM 125, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-A (1977).
[5] Sleva, S .F. Determination of Formaldehyde: Chromotropic Acid Method, PHS Publication 999-AP-11, H-1 (1965).
[6a] "Methods of Air Sampling and Analysis," Method 111, Intersociety Committee for a Manual of Methods of Air Sampling and Analysis, American Public Health Association, Washington, DC, 194-198 (1972).
[6b] M.Katz, ed., "Methods of Air Sampling and Analysis," 2nd ed., Intersociety Committee on Methods of Air Sampling and Analysis, American Public Health Association, Washington, DC, Method 116, 303-307 (1977).
[7] NIOSH Manual of Analytical Methods, 2nd ed., V.6, P&CAM 318, U.S. Department of Health and Human Services, Publ. (NIOSH) 80-125 (1980)
[8] Beasley, R. K., C. E. Hoffmann, M. L. Reuppel and J. W. Worley. Anal. Chem., 52, 1110-1114 (1980).
[9] Kennedy, E. R., D. L. Smith, M. Bolyard and R. Hornung. Further Adventures in Formaldehyde Sampling and Analysis, Poster Session at 1982 American Industrial Hygiene Conference, Cincinnati, OH (1982).

METHOD REVISED BY: Eugene R. Kennedy, Ph.D., NIOSH/DPSE.

APPENDIX:

PREPARATION AND STANDARDIZATION OF FORMALDEHYDE STOCK SOLUTION (ca. 1 mg/mL)
Dilute 2.7 mL 37% formalin solution to 1 L with distilled, deionized water. Standardize as follows:

Place 5.0 mL 1.13 N sodium sulfite solution in a 50-mL beaker, stirred with a magnetic stirrer. Adjust pH to between 7 and 9 with base or acid. Record the pH. Pipet 10.0 mL stock formaldehyde solution into the beaker. The pH should now be about 12. Titrate the solution back to its original pH with 0.02 N sulfuric acid. (1 mL of 0.02 N sulfuric acid = 0.600 mg HCHO; about 17 mL acid needed.) Calculate the concentration, C_s (mg/mL), of the stock formaldehyde solution:

$$C_s = \frac{30.0 \cdot [(N_a \cdot V_a) - (N_b \cdot V_b)]}{V_s}$$

where: 30.0 = 30.0 g/equivalent of formaldehyde
N_a = normality of sulfuric acid
V_a = volume of acid (mL) used for titration
N_b = normality of NaOH
V_b = volume of NaOH (mL) used for back titration
V_s = volume of HCHO stock solution (10.0 mL).

APPENDIX C

MODELING RESULTS

Colorado Department of Health
Air Pollution Control Division
INTER-OFFICE COMMUNICATION

TO: Cathy Rhodes

DATE: March 19, 1987

FROM: A. Dresser AD

SUBJECT: Additional L-P Olathe Modeling

The ISCST dispersion model was used to estimate the impacts of TSP and formaldehyde based on the revised emission rates you provide. The impact of MDI was obtained by scaling the results of an earlier analysis (memo to Jim Geier dated August 20, 1987). Five years of hourly meteorological data (1977-81) from Grand Junction was used in the modeling. Concentrations were calculated at 39 receptor locations. The overall modeling procedure that was followed is similar to that outlined in a November 21, 1985 memo to you. That memo described the PSD modeling done for Olathe.

The stack parameters and emission rates used are given below.

	Konus	Wafer Dryer	West Vent	East Vent
Stack Ht.(m)	22.9	30.5	19.8	19.8
Gas Temp. (K^o)	511	373	305	307
Exit Vel. (m/s)	29.8	19.3	9.4	12.4
Stack Dia (m)	0.8	1.2	1.6	1.6
TSP (g/s)	0.09	2.26	0.54	0.53
formaldehyde (g/s)	0.0	1.35	0.02	0.02
MDI (g/s)	0.0	0.0025	0.0038	0.0038

Results are given in Table 1. The annual TSP concentration was scaled up from the 24-hour concentration using a factor of 0.25.

TABLE 1

Maximum Impacts Due to the L-P Olathe Facility

Pollutant	Averaging Time	Date	Receptor	Concentration (ug/m^3)
Formaldehyde	1-hour	12/23/81 (hr. 4)	18	62.0
	8-hour	6/07/77 (hrs. 9-16)	8	27.4
	24-hour	5/06/77	8	15.0
TSP	1-hour	7/26/77 (hr. 22)	20	403.3
	24-hour	5/06/77	8	38.8
	Annual	1977		9.7
MDI	1-hour	8/01/81 (hr. 24)	20	2.76
	8-hour	9/29/78 (hrs. 17-24)	20	0.55
	24-hour	7/25/77	20	0.23
	annual	1978	12	0.04

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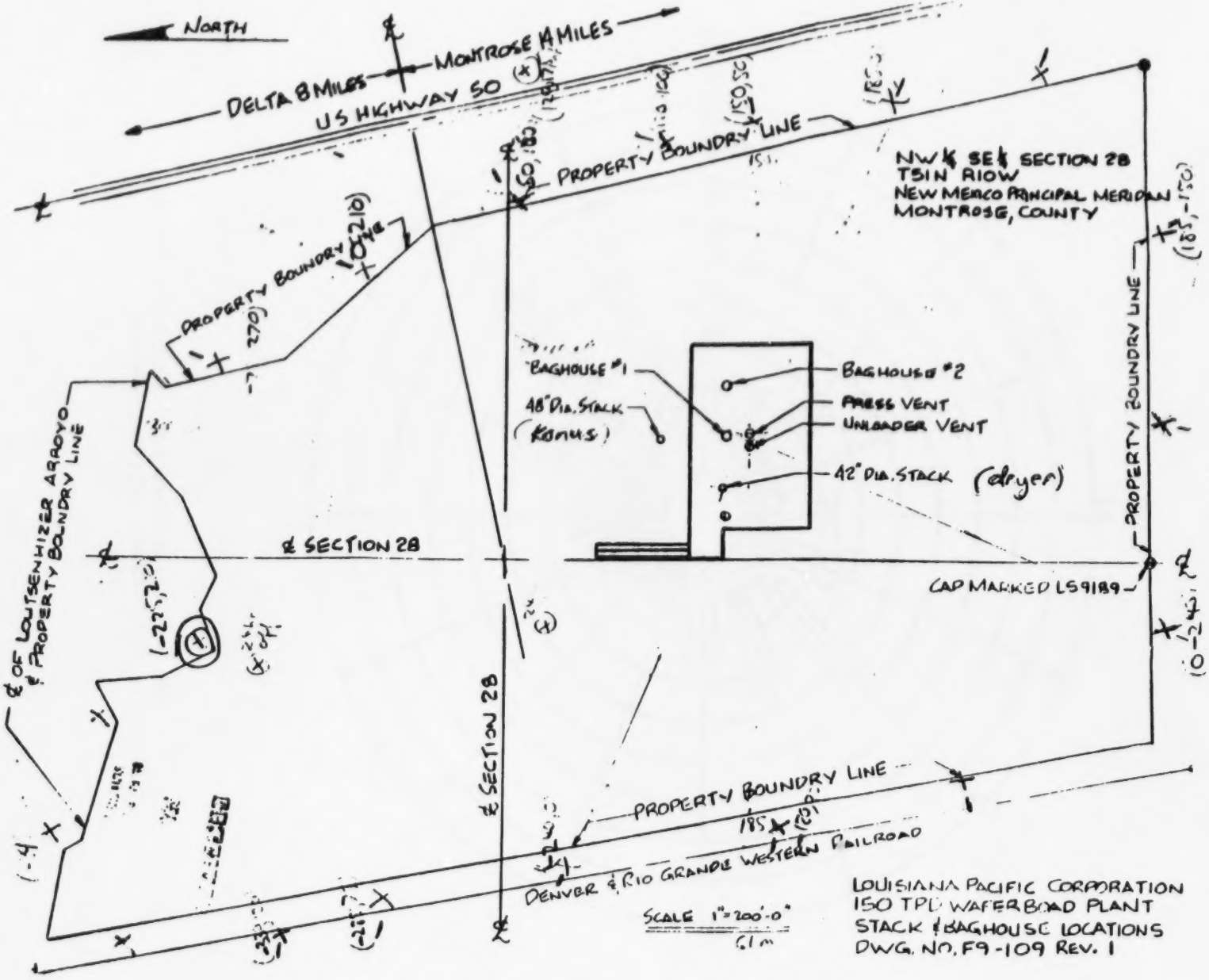

NORTH
DELTA 8 MILES
MONTROSE 4 MILES
US HIGHWAY 50
PROPERTY BOUNDRY LINE
NW¼ SE¼ SECTION 28
T5IN R10W
NEW MEXICO PRINCIPAL MERIDIAN
MONTROSE, COUNTY
PROPERTY BOUNDRY LINE
BAGHOUSE #1
BAGHOUSE #2
48" DIA. STACK
(ROTUS)
PRESS VENT
UNLOADER VENT
42" DIA. STACK (dryer)
℄ SECTION 28
℄ OF LOUTSENHIZER ARROYO
& PROPERTY BOUNDRY LINE
CAP MARKED LS9189
℄ SECTION 28
PROPERTY BOUNDRY LINE
DENVER & RIO GRANDE WESTERN RAILROAD
SCALE 1"=200'-0"
61 m
LOUISIANA PACIFIC CORPORATION
150 TPD WAFERBOARD PLANT
STACK & BAGHOUSE LOCATIONS
DWG. NO. F9-109 REV. 1

C-3

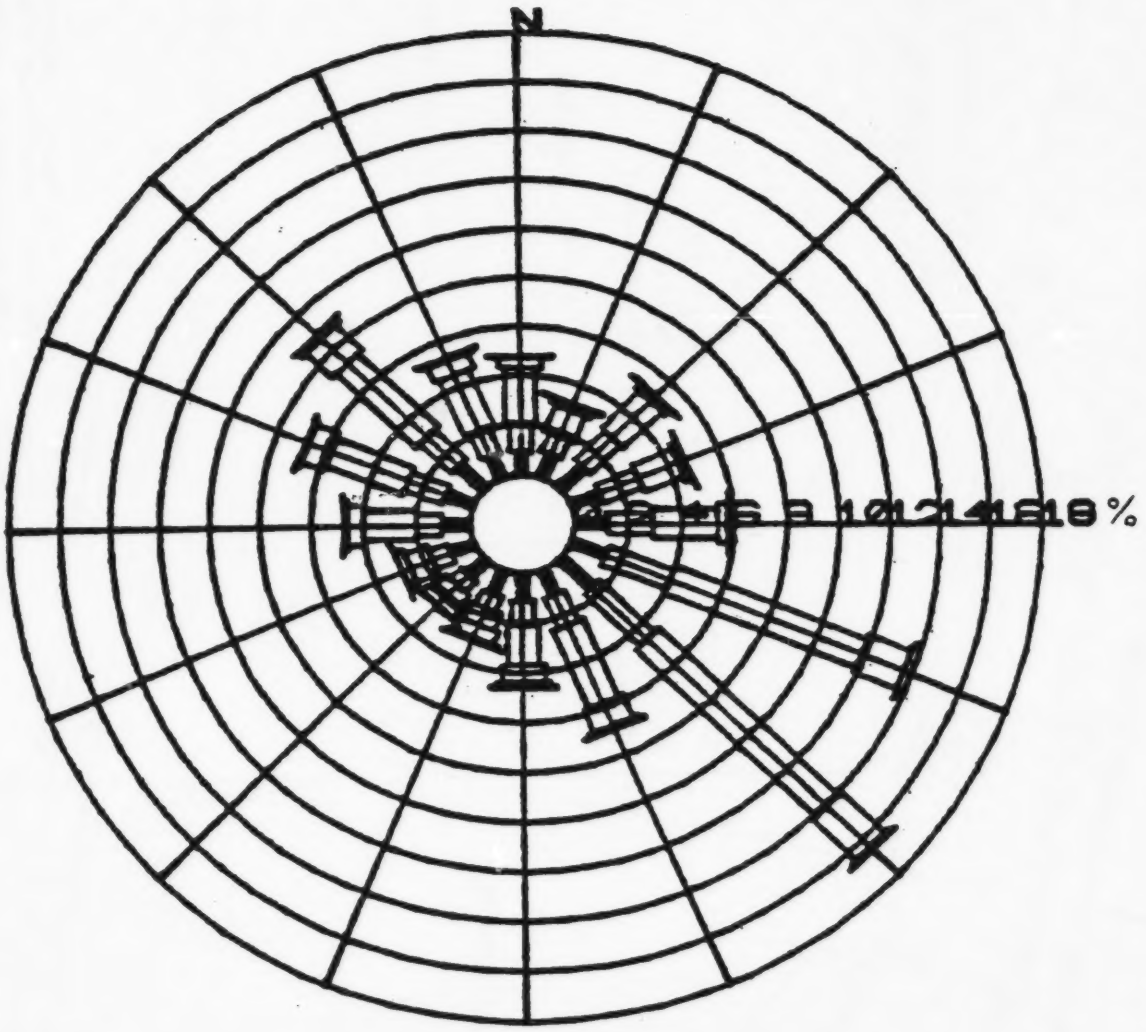


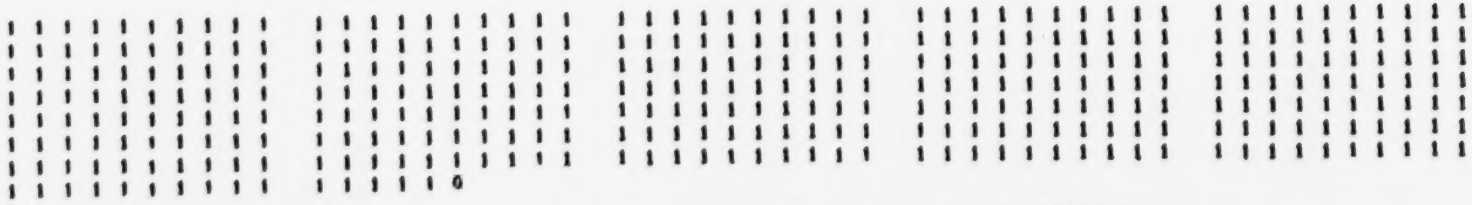
FIGURE 4-2 Wind Frequency Distribution Plot for Grand Junction, Colorado (1977-1981)

*** LOUISIANA-PACIFIC OLATHE ***

CALCULATE (CONCENTRATION=1,DEPOSITION=2)	ISW(1) =	1
RECEPTOR GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)	ISW(2) =	1
DISCRETE RECEPTOR SYSTEM (RECTANGULAR=1,POLAR=2)	ISW(3) =	1
TERRAIN ELEVATIONS ARE READ (YES=1,NO=0)	ISW(4) =	1
CALCULATIONS ARE WRITTEN TO TAPE (YES=1,NO=0)	ISW(5) =	0
LIST ALL INPUT DATA (NO=0,YES=1,MET DATA ALSO=2)	ISW(6) =	1
COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION)		
WITH THE FOLLOWING TIME PERIODS:		
HOURLY (YES=1,NO=0)	ISW(7) =	1
2-HOUR (YES=1,NO=0)	ISW(8) =	0
3-HOUR (YES=1,NO=0)	ISW(9) =	0
4-HOUR (YES=1,NO=0)	ISW(10) =	0
6-HOUR (YES=1,NO=0)	ISW(11) =	0
8-HOUR (YES=1,NO=0)	ISW(12) =	0
12-HOUR (YES=1,NO=0)	ISW(13) =	0
24-HOUR (YES=1,NO=0)	ISW(14) =	1
PRINT ANY-DAY TABLE(S) (YES=1,NO=0)	ISW(15) =	1
PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE		
SPECIFIED BY ISW(7) THROUGH ISW(14):		
DAILY TABLES (YES=1,NO=0)	ISW(16) =	0
HIGHEST & SECOND HIGHEST TABLES (YES=1,NO=0)	ISW(17) =	1
MAXIMUM 50 TABLES (YES=1,NO=0)	ISW(18) =	0
METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1,CARD=2)	ISW(19) =	1
TERRAIN OPTION (RU.=0,UR. MODE 1=1,UR. MODE 2=2,UR. MODE 3=3)	ISW(20) =	0
WIND PROFILE EXPONENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(21) =	1
VERTICAL POT. TEMP. GRADIENT VALUES (DEFAULTS=1,USER ENTERS=2,3)	ISW(22) =	1
SCALE EMISSION RATES FOR ALL SOURCES (NO=0,YES>0)	ISW(23) =	0
PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1,NO=2)	ISW(24) =	2
PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWASH (YES=2,NO=1)	ISW(25) =	2
PROGRAM USES BUOYANCY INDUCED DISPERSION (YES=1,NO=2)	ISW(26) =	2
CONCENTRATIONS DURING CALM PERIODS SET = 0 (YES=1,NO=2)	ISW(27) =	1
REG. DEFAULT OPTION CHOSEN (YES=1,NO=2)	ISW(28) =	2
TYPE OF POLLUTANT TO BE MODELLED (1=SO2,2=OTHER)	ISW(29) =	2
DEBUG OPTION CHOSEN (1=YES,2=NO)	ISW(30) =	2
NUMBER OF INPUT SOURCES	NSOURC =	4
NUMBER OF SOURCE GROUPS (=0,ALL SOURCES)	NGROUP =	0
TIME PERIOD INTERVAL TO BE PRINTED (=0,ALL INTERVALS)	IPERD =	0
NUMBER OF X (RANGE) GRID VALUES	NXPNTS =	0
NUMBER OF Y (RANGE) GRID VALUES	NYPNTS =	0
LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA	IMET =	9
DECAY COEFFICIENT FOR PHYSICAL OR CHEMICAL DEPLETION	DECAY =	0.0
SURFACE STATION NO.	ISS =	23066
YEAR OF SURFACE DATA	ISY =	81
UPPER AIR STATION NO.	IUS =	23066
YEAR OF UPPER AIR DATA	IUY =	81
ALLOCATED DATA STORAGE	LIMIT =	43500 WORDS
REQUIRED DATA STORAGE FOR THIS PROBLEM RUN	MINIT =	1484 WORDS

*** LOUISIANA-PACIFIC OLATHE ***

*** METEOROLOGICAL DAYS TO BE PROCESSED ***
(IF=1)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*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.0	.0	.0	.0	.0	.0
B	.0	.0	.0	.0	.0	.0
C	.0	.0	.0	.0	.0	.0
D	.0	.0	.0	.0	.0	.0
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** LOUISIANA-PACIFIC ULATHE ***

*** X,Y COORDINATES OF DISCRETE RECEPTORS ***
(METERS)

500.0,	0.0),	(55.0,	260.0),	(890.0,	1542.0),	(-1926.0,	2140.0),	(-1391.0,	-562.0),
125.0,	175.0),	(150.0,	50.0),	(60.0,	160.0),	(-225.0,	210.0),	(-240.0,	0.0),
185.0,	0.0),	(185.0,	-150.0),	(120.0,	100.0),	(0.0,	210.0),	(0.0,	-240.0),
-330.0,	120.0),	(195.0,	65.0),	(170.0,	120.0),	(0.0,	260.0),	(235.0,	0.0),
-265.0,	75.0),	(-375.0,	180.0),	(-285.0,	270.0),	(-345.0,	270.0),	(-335.0,	75.0),
-425.0,	180.0),	(-290.0,	0.0),	(-120.0,	-165.0),	(-180.0,	-90.0),	(-165.0,	-175.0),
-215.0,	-125.0),	(0.0,	-290.0),	(-70.0,	270.0),	(-80.0,	315.0),	(90.0,	-195.0),
230.0,	-60.0),	(100.0,	-240.0),	(275.0,	-65.0),	(220.0,	-1850.0),	(	

*** LOUISIANA-PACIFIC OLATHE ***

* ELEVATION HEIGHTS IN METERS *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	HGT.	- X -	- Y -	HGT.	- X -	- Y -	HGT.
500.0	0.0	12.19203	55.0	260.0	12.19203	890.0	1542.0	18.28802
-1926.0	2140.0	0.0	-1391.0	-562.0	12.19203	125.0	175.0	6.09601
150.0	50.0	6.09601	60.0	160.0	6.09601	-225.0	210.0	0.0
-246.0	0.0	0.0	185.0	0.0	6.09601	185.0	-150.0	6.09601
120.0	100.0	6.09601	0.0	210.0	6.09601	0.0	-240.0	0.0
-330.0	120.0	0.0	195.0	65.0	12.19203	170.0	120.0	12.19203
0.0	260.0	12.19203	235.0	0.0	12.19203	-285.0	75.0	0.0
-375.0	180.0	0.0	-285.0	270.0	0.0	-345.0	270.0	0.0
-335.0	75.0	0.0	-425.0	180.0	0.0	-290.0	0.0	0.0
-120.0	-165.0	0.0	-180.0	-90.0	0.0	-165.0	-175.0	0.0
-215.0	-175.0	0.0	0.0	-290.0	0.0	-70.0	270.0	0.0
-80.0	315.0	0.0	90.0	-195.0	0.0	230.0	-60.0	6.09601
100.0	-240.0	0.0	275.0	-65.0	0.0	220.0	-1850.0	0.0

*** SOURCE DATA ***

SOURCE ID	EMISSION RATE TYPE=0,1 (GRAMS/SEC) TYPE=2 (GRAMS/SEC/METER**2)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	HEIGHT (METERS)	TEMP. TYPE=0 (DEG.K); VERT.DIM TYPE=1 (METERS)	EXIT VEL. TYPE=0 (M/SEC); HORZ.DIM TYPE=1,2 (METERS)	DIAMETER TYPE=0 (METERS)	BLDG. HEIGHT TYPE=0 (METERS)	BLDG. LENGTH TYPE=0 (METERS)	BLDG. WIDTH TYPE=0 (METERS)
1	0.0	-18.0	65.0	0.0	22.90	511.00	29.80	0.80	19.80	41.50	41.50
2	0.13500E+01	-30.0	5.0	0.0	30.50	373.00	19.10	1.20	19.80	41.50	41.50
3	0.20000E-01	3.0	3.0	0.0	19.80	307.00	12.40	1.60	19.80	41.50	41.50
4	0.20000E-01	0.0	-5.0	0.0	19.80	305.00	9.40	1.60	19.80	41.50	41.50

CALM HOURS (=1) FOR DAY	1	*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
CALM HOURS (=1) FOR DAY	2	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0				
CALM HOURS (=1) FOR DAY	4	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0				
CALM HOURS (=1) FOR DAY	5	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0				
CALM HOURS (=1) FOR DAY	6	*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	8	*	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	10	*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	11	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	12	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1				
CALM HOURS (=1) FOR DAY	13	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	14	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	15	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	1	0	1	0				
CALM HOURS (=1) FOR DAY	16	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0				
CALM HOURS (=1) FOR DAY	17	*	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	18	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0				
CALM HOURS (=1) FOR DAY	19	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	20	*	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0				
CALM HOURS (=1) FOR DAY	21	*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	23	*	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	25	*	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	26	*	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CALM HOURS (=1) FOR DAY	27	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0				
CALM HOURS (=1) FOR DAY	28	*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0				
CALM HOURS (=1) FOR DAY	29	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0				
CALM HOURS (=1) FOR DAY	30	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0				
CALM HOURS (=1) FOR DAY	31	*	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1				
CALM HOURS (=1) FOR DAY	32	*	1	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0				

*** LOUISIANA-PACIFIC OLATHE ***

* 365-DAY AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *

* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	CON.	- X -	- Y -	CON.	- X -	- Y -	CON.
500.0	0.0	0.53929	55.0	260.0	0.22094	890.0	1542.0	0.05920
-1926.0	2148.0	0.19410	-1391.0	-562.0	0.14341	125.0	175.0	0.15923
150.0	50.0	0.29365	60.0	160.0	0.15672	-225.0	210.0	0.72647
-240.0	0.0	0.38538	185.0	0.0	0.57262	185.0	-150.0	0.74174
120.0	100.0	0.20905	0.0	210.0	0.28595	0.0	-240.0	0.22350
-330.0	120.0	0.56683	195.0	65.0	0.38642	170.0	120.0	0.29444
0.0	260.0	0.36938	235.0	0.0	0.73246	-285.0	75.0	0.51967
-475.0	180.0	0.76442	-285.0	270.0	0.73672	-345.0	270.0	0.89669
-335.0	75.0	0.38736	-425.0	180.0	0.60913	-290.0	0.0	0.26876
-120.0	-165.0	0.15809	-180.0	-90.0	0.32212	-165.0	-175.0	0.23288
-215.0	-125.0	0.25861	0.0	-290.0	0.19336	-70.0	270.0	0.23638
-80.0	315.0	0.25107	90.0	-195.0	0.29268	230.0	-60.0	0.49563
100.0	-240.0	0.29110	275.0	-65.0	0.33865	220.0	-1850.0	0.09470

*** LOUISIANA-PACIFIC OLATHE ***

* HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	CON.	(DAY,HOUR)	- X -	- Y -	CON.	(DAY,HOUR)
500.0	0.0	24.28	(236,16)	55.0	260.0	42.02	(159,20)
890.0	1542.0	18.07	(185,24)	-1926.0	2140.0	7.28	(284, 3)
-1391.0	-562.0	12.98	(161, 4)	125.0	175.0	50.70	(273,21)
150.0	50.0	39.83	(323, 1)	60.0	160.0	39.39	(235,20)
-225.0	210.0	24.83	(284, 3)	-240.0	0.0	27.07	(232, 1)
185.0	0.0	34.12	(233,11)	185.0	-150.0	28.13	(214,18)
120.0	100.0	43.01	(188,20)	0.0	210.0	37.95	(163,20)
0.0	-240.0	18.23	(164, 4)	-330.0	120.0	16.88	(213,11)
195.0	65.0	45.03	(186,17)	170.0	120.0	54.36	(357, 4)
0.0	260.0	38.99	(232,21)	235.0	0.0	41.07	(218,16)
-285.0	75.0	18.37	(211, 4)	-375.0	180.0	16.05	(195,23)
-245.0	270.0	22.49	(284, 3)	-345.0	270.0	16.13	(163, 8)
-335.0	75.0	17.59	(177,21)	-425.0	180.0	14.64	(189,24)
-290.0	0.0	19.49	(108, 3)	-120.0	-165.0	26.68	(262,20)
-180.0	-90.0	32.68	(229,24)	-165.0	-175.0	23.69	(208,22)
-215.0	-125.0	24.21	(336, 1)	0.0	-290.0	15.99	(205,18)
-70.0	270.0	17.41	(176,22)	-80.0	315.0	16.45	(176,22)
90.0	-195.0	20.32	(174,23)	230.0	-60.0	29.66	(159,17)
100.0	-240.0	17.91	(221,16)	275.0	-65.0	19.37	(174,16)
220.0	-1850.0	9.74	(356, 9)				

*** LOUISIANA-PACIFIC OLATHE ***

* SECOND HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	CON.	(DAY,HOUR)	- X -	- Y -	CON.	(DAY,HOUR)
500.0	0.0	24.19	(187,21)	55.0	260.0	37.96	(271,17)
890.0	1542.0	14.66	(80,23)	-1926.0	2140.0	5.98	(182, 4)
-1391.0	-562.0	11.59	(230, 1)	125.0	175.0	33.35	(184,24)
150.0	50.0	35.03	(108,16)	60.0	160.0	35.58	(116,15)
-225.0	210.0	19.08	(177,10)	-240.0	0.0	26.81	(182, 4)
185.0	0.0	33.91	(218,16)	185.0	-150.0	27.44	(154,22)
120.0	100.0	37.65	(171,20)	0.0	210.0	35.92	(260, 5)
0.0	-240.0	17.72	(115,19)	-330.0	120.0	15.89	(246, 8)
195.0	65.0	43.96	(158,15)	170.0	120.0	48.63	(357, 3)
0.0	260.0	36.64	(267,20)	235.0	0.0	40.14	(229,17)
-285.0	75.0	18.15	(266, 2)	-375.0	180.0	15.73	(240, 1)
-285.0	270.0	17.66	(177,10)	-345.0	270.0	15.76	(209,24)
-335.0	75.0	17.10	(190, 1)	-425.0	180.0	14.57	(206,12)
-290.0	0.0	19.47	(232, 1)	-120.0	-165.0	25.26	(69,23)
-189.0	-90.0	31.82	(38, 4)	-165.0	-175.0	22.67	(171,23)
-215.0	-125.0	23.56	(296,23)	0.0	-290.0	15.78	(193,24)
-79.0	270.0	14.30	(177,22)	-80.0	315.0	15.22	(125,17)
90.0	-195.0	20.20	(111,23)	230.0	-60.0	29.40	(185,16)
100.0	-240.0	17.64	(203,18)	275.0	-65.0	19.24	(159,14)
220.0	-1850.0	7.20	(281,15)				

*** LOUISIANA-PACIFIC OLATHE ***

* HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	CON.	(DAY,PER)	- X -	- Y -	CON.	(DAY,PER)
500.0	0.0	3.15	(229, 1)	55.0	260.0	2.48 C	(92, 1)
890.0	1542.0	0.79 C	(185, 1)	-1926.0	2140.0	0.91	(241, 1)
-1391.0	-562.0	1.12 C	(94, 1)	125.0	175.0	4.34	(163, 1)
150.0	50.0	4.45 C	(158, 1)	60.0	160.0	3.64	(116, 1)
-225.0	210.0	3.89 C	(243, 1)	-240.0	0.0	3.05	(208, 1)
185.0	0.0	4.28	(131, 1)	185.0	-150.0	5.31	(164, 1)
120.0	100.0	3.20 C	(92, 1)	0.0	210.0	5.14	(56, 1)
0.0	-240.0	2.36	(334, 1)	-330.0	120.0	4.18 C	(42, 1)
195.0	65.0	5.68 C	(158, 1)	170.0	120.0	5.15 C	(357, 1)
0.0	260.0	5.59	(56, 1)	235.0	0.0	4.89	(171, 1)
-285.0	75.0	3.66 C	(42, 1)	-375.0	180.0	3.33	(210, 1)
-245.0	270.0	4.01 C	(243, 1)	-345.0	270.0	4.94	(277, 1)
-335.0	75.0	2.13	(190, 1)	-425.0	180.0	3.52 C	(42, 1)
-290.0	0.0	2.20	(208, 1)	-120.0	-165.0	1.47	(259, 1)
-180.0	-90.0	3.36 C	(38, 1)	-165.0	-175.0	1.95 C	(124, 1)
-215.0	-125.0	2.06	(207, 1)	0.0	-290.0	1.73	(334, 1)
-70.0	270.0	2.22	(125, 1)	-80.0	315.0	2.23	(125, 1)
90.0	-195.0	2.89	(137, 1)	230.0	-60.0	4.29	(155, 1)
100.0	-240.0	2.34	(137, 1)	275.0	-65.0	3.28	(155, 1)
220.0	-1850.0	0.98 C	(87, 1)				

*** LOUISIANA-PACIFIC OLATHE ***

* SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE DISCRETE RECEPTOR POINTS *

- X -	- Y -	CON.	(DAY,PER)	- X -	- Y -	CON.	(DAY,PER)
500.0	0.0	3.11	(171, 1)	55.0	260.0	2.26	(140, 1)
890.0	1542.0	0.63 C	(31, 1)	-1926.0	2140.0	0.85	(254, 1)
-1391.0	-562.0	1.03	(306, 1)	125.0	175.0	2.92 C	(273, 1)
150.0	50.0	2.87	(253, 1)	60.0	160.0	2.39	(104, 1)
-225.0	210.0	3.46	(205, 1)	-240.0	0.0	1.97	(254, 1)
185.0	0.0	4.07 C	(93, 1)	185.0	-150.0	5.17	(165, 1)
120.0	100.0	3.09 C	(357, 1)	0.0	210.0	4.82	(85, 1)
0.0	-240.0	1.87	(137, 1)	-330.0	120.0	3.33	(271, 1)
195.0	65.0	3.64 C	(230, 1)	170.0	120.0	3.90 C	(156, 1)
0.0	260.0	5.57	(85, 1)	235.0	0.0	4.75	(229, 1)
-285.0	75.0	2.71	(321, 1)	-375.0	180.0	3.26	(206, 1)
-245.0	270.0	3.79	(205, 1)	-345.0	270.0	4.19	(205, 1)
-335.0	75.0	1.94	(321, 1)	-425.0	180.0	3.47	(301, 1)
-290.0	0.0	1.46	(246, 1)	-120.0	-165.0	1.23 C	(245, 1)
-180.0	-90.0	2.40	(207, 1)	-165.0	-175.0	1.70 C	(245, 1)
-215.0	-125.0	1.09 C	(336, 1)	0.0	-290.0	1.60	(137, 1)
-70.0	270.0	2.09	(281, 1)	-80.0	315.0	2.20	(281, 1)
90.0	-195.0	2.30 C	(111, 1)	230.0	-60.0	3.80	(160, 1)
100.0	-240.0	2.34	(334, 1)	275.0	-65.0	2.39	(160, 1)
220.0	-1850.0	0.95	(334, 1)				